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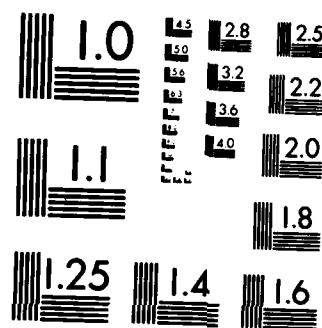
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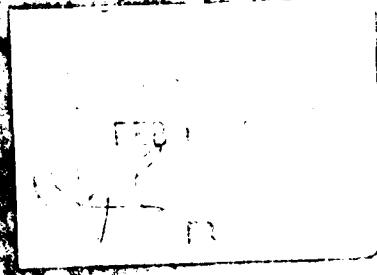
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GEOPOLITICS OF STRATEGIC MINERALS: THE EXAMPLE OF CHROMIUM

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A thesis submitted to The University of Texas at Austin, Austin, Texas  
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Arts.

GEOPOLITICS OF STRATEGIC MINERALS:  
THE EXAMPLE OF CHROMIUM

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GEOPOLITICS OF STRATEGIC MINERALS:  
THE EXAMPLE OF CHROMIUM

BY

JOHN RICHARD SARVER, B.S.

THESIS

Presented to the Faculty of the Graduate School of  
The University of Texas at Austin  
in Partial Fulfillment  
of the Requirements  
for the Degree of

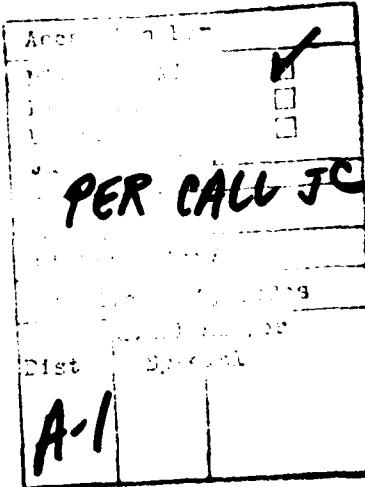
MASTER OF ARTS

THE UNIVERSITY OF TEXAS AT AUSTIN

~~December 1984~~  
20 AUGUST 1984

## DEDICATION

This work is dedicated to Jesus Christ, who created me; to my Dad, Dick, who molded me into the man I am today; to my Mom, Jane, from who I inherited the ability to do this work; and especially to my wife, Mary Beth, whose constant love, confidence and positive-thinking inspires me and makes my life complete. I love them all very much.



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First, heartfelt thanks to my committee chairman, Dr. Paul Anaejionu. As my first Energy and Mineral Resources (EMR) instructor, he helped me develop a methodology for examining the unique problems related to minerals policy analysis. He helped me trim an unmanagable thesis topic into this timely analysis of how the government can handle strategic and critical minerals policy formulation by looking at the options for a key commodity. Our talks rejuvenated my spirit as I related very closely to his ideas and his ideals.

Also, special thanks to Dr. WCJ van Rensburg whose advice and intriguing courses really spurred my interest in energy and mineral studies. I hope the association of our U.S. Army petroleum management officers will continue with the EMR program that he directs.

Finally, thanks to Dr. Victor L. Arnold for his kind assistance despite the hectic workload of a University Administrator.

The contributions given by these individuals made this work possible. Their assistance is most gratefully acknowledged. Further, any error in information or analysis is the sole responsibility of the author.

## ABSTRACT

The United States Government has identified 93 specific commodities in 61 mineral family catagories as critical and strategic. Some are considered more strategic and critical than others. A high import dependence, significant defense and industrial application, and uncertainty about foreign supplies to the United States are factors contributing to the strategic and critical nature of a mineral or material.

United States strategic minerals import vulnerability is also increasing, generally due to increasing import dependence and to the surrogate intervention of the Soviet Union in southern Africa, the world's most mineral rich region. Zaire, Zimbabwe, and the Republic of South Africa are the supply sources of major U.S. concern. The idea of a Soviet "Resource War" against the U.S. for oil and strategic minerals has been reinforced by numerous resource analysts.

To understand the policy options that the United States has for the secure supplies of strategic minerals, one must examine the geopolitical factors that influence individual minerals markets. Chromium is one of the most strategic and critical of all minerals to the U.S. Examination of the U.S. and global chromium market will lead to a better understanding of U.S. policy options that

may be applicable to many other strategic minerals. Chromium also provides the basis for examining the U.S. import dependence on ores and concentrates (i.e. chromite), versus import dependence on the processed form of a mineral (i.e. ferrochrome). Generally the strategic advantage belongs to the country that does most of a mineral's processing, whether it be the producing or the consuming country. They gain the added value of processed materials over ores. Ore producers who do the processing also incur lower transportation costs in exporting their goods. The dire straits faced by the U.S. ferrochrome processing industry make it a fascinating case study of how foreign policy options are formulated.

Generally, economics rules decision making in mineral markets. However, governments may choose to support uneconomic mineral production programs or financially support other activities (i.e. R&D, stockpiling, foreign aid, exploration, substitution, recycling, etc.) if they are viewed as decreasing minerals import vulnerability.

This paper provides specific conclusions and recommendations regarding U.S. chromium import dependence. Then, on the basis of findings from the present study, selected elements of mineral policy options are recommended for further study.

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## CHAPTER I

### INTRODUCTION

In 1979, the New York based National Strategy Information Center Published a 100 page report entitled, Raw Material Supply in a Multipolar World, concerning U.S. import dependence of minerals. Relevant extracts are:

...This confirms what defense analysts know all too well but the American press, public and Congress are only belatedly starting to realize: that the United States faces a potential mineral crisis which could grind American industry to a screeching halt and create worldwide economic chaos.

...This strongly suggests that the Soviet Union, having achieved military parity with the United States virtually across the board-and military superiority in a number of areas - now may be attempting to gain monopolistic control of a number of key strategic metals and minerals without which the United States and its free world allies would be militarily helpless.

The United States has identified 61 materials as strategic and critical to the future of domestic industries and the defense establishment.<sup>2</sup> Our mineral import dependence is subjectively measured as a function of numerous supply and demand factors worldwide. Some minerals are considered more strategic and critical to U.S. interests than others. A higher import dependence, greater defense/industrial application, and stronger uncertainty about uninterrupted import availability at "fair" prices all add to the strategic and critical nature of a mineral or material.

This study looks at those factors that influence

the security of mineral supplies for the United States. It is meaningless to look at U.S. nonfuel mineral policy without analyzing individual commodities. This is an attempt to do exactly that by looking at a key commodity and the policy options applicable to that commodity. Because chromium is one of the most strategic minerals to the United States, this country faces potentially serious problems in both the chromite ore and ferrochromium world markets. This is one way a meaningful nonfuel mineral policy can be developed.

This thesis will look at the problems from the United States "consumer" perspective, not the South Africa "producer" perspective. The purpose of this study is twofold:

- 1) To examine the United States' import dependence and vulnerability to supply disruption for chromite and ferrochrome as key representatives of our strategic and critical minerals.
- 2) To identify problems and make recommendations concerning geopolitical policy options the United States might exercise in dealing with this import dependence.

Chapter 2 examines the issue of critical and strategic materials by presenting a background discussion of the "resource war" debate. The basis of this resource war is increasing U.S. import dependence for strategic minerals and what many authors believe is the Soviet

Union's desire or attempts to deny the U.S. and its western allies access to critical and strategic minerals coming from regions such as southern Africa.

Chapter 3 presents an in-depth discussion of chromium. Topics covered include the following; world chromite reserves, world and U.S. production of chromium, U.S. strategic end uses of chromium, domestic consumption of chromium by industrial sectors, U.S. import dependence for chromite and ferrochrome, and a world market outlook for chromium up to the year 2000.

Chapter 4 looks at the demise of the domestic ferrochrome industry. Technological improvements in chromium utilization led to market factors that favor the production of ferrochrome by those countries endowed with chromite reserves, low-cost energy, and less stringent environmental constraints. These technological advances have created market changes that have caused serious problems for the domestic ferrochrome industry. Market investigations have led to presidential decisions that often do not satisfy special interest groups affiliated with the U.S. ferrochrome industry.

Chapter 5 looks at policy options available to decrease U.S. vulnerability to chromium supply disruption. This chapter goes into the supply diversification option by pointing out the comparative market advantages and disadvantages germane to the major chromium producers of

the world. Their current and future relationships with the U.S. government and her ferrochromium market are a key concern. Security of imported chromium supply is a U.S. goal.

Chapter 6 takes a look at some typical U.S. government-derived, supply disruption scenarios for chromium. Then it attempts to analyze policy options available to combat this perceived lack of security for chromium imports into the U.S.

The methods used to evaluate chromium may be applied in the study of various strategic minerals so as to derive policy options for United States import dependence problems.

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1. Wu, Yuan-li. Raw Material Supply in a Multipolar World. Second Edition. National Strategy Information Center, Inc. New York: Crane, Russak & Company, Inc., 1979.
2. U.S. Federal Emergency Management Agency. Stockpile Report to the Congress. Washington, D.C.: Government Printing Office, April 1984.

## CHAPTER II

### RESOURCE WAR: BACKGROUND DISCUSSION

#### INTRODUCTION AND DESCRIPTION OF KEY CONCEPTS

This chapter focuses on the concept of a resource war over key non-fuel minerals. The major participants in this battle are the USA and the USSR, with southern Africa mineral supplies being the objective. Soviet denial strategies are countered by U.S. strategies that attempt to at least maintain secure supplies from southern Africa producers of critical and strategic minerals.

In the past several years, mineral analysts have disagreed on the theory the Soviet Union is involved in a "Resources War" with the United States. Table II-1 is extracted from Philip Ballinger's May 83 thesis on the minerals industry of the U.S.S.R.,<sup>1</sup> providing a summary, although not exhaustive, survey of various authors' positions on that debate. This jury of experts appears to lean toward interpreting Russian activities in southern Africa as resources-related. With so many experts in agreement, this study begins by accepting the assumption that the Soviet Union is indeed waging some type of "resource war" against the United States and it's industrialized allies.

Which minerals are critical and strategic, and why, will vary from country to country, and among different industries and different users at different

TABLE II-1  
OPINIONS OF VARIOUS AUTHORS REGARDING  
SOVIET INTENTIONS IN SOUTHERN AFRICA

<u>AUTHOR</u>	<u>RESOURCES-RELATED</u>	<u>NOT RESOURCES-RELATED</u>
Strauss <sup>2</sup>	XX	
Szuprowicz (21st Century Research) <sup>3</sup>	XX	
Fine <sup>4</sup>	XX	
Shabad <sup>5</sup>		XX
Vogely <sup>6</sup>		XX
Strishkov (BOM) <sup>7</sup>		XX
Bowman <sup>8</sup>		XX
Shafer <sup>9</sup>		XX
Rees (Institute for the study of Conflict) <sup>10</sup>	XX	
Council of Economics and National Security <sup>11,12</sup>	XX	
Resources for the Future <sup>13</sup>		XX
<u>Soviet Analyst</u> <sup>14</sup>		
Meyer <sup>15</sup>	XX	
Tilton & Landsberg <sup>16</sup>		XX
Foreign Affairs Research Institute <sup>17</sup>	XX	
ALARM (Miller) <sup>18</sup>	XX	
South African Embassy <sup>19</sup>	XX	
Slay <sup>20</sup>	XX	

Source: 1

times. By U.S. law (Strategic and Critical Materials Stockpiling Revision Act of 1979, Public Law 96-41), "strategic and critical materials" are defined as materials that (1) would be needed to supply the military, industrial, and essential civilian needs of the United States during a national defense emergency, and (2) are not found or produced in the United States in sufficient quantities to meet such needs. The term "national defense emergency" means a general declaration of emergency with respect to the national defense made by the President or by the Congress.<sup>21</sup>

As of March 31, 1984, 61 minerals and materials are classified as strategic and critical and are, therefore, stockpiled in a national inventory. These 61 strategic and critical materials are considered in 93 different forms.<sup>22</sup> Some are considered more strategic and critical than others. Minerals considered the most critical and strategic to United States' interests are chromium, manganese, platinum group elements, cobalt, bauxite and tantalum.

#### **THE HISTORIC STRUGGLE OVER STRATEGIC AND CRITICAL MINERALS**

In his book entitled, The United States and the Global Struggle for Minerals,<sup>23</sup> Alfred Eckes does an outstanding job showing how U.S. minerals analysts have been concerned about diminishing domestic supplies of minerals since before World War I. He presents the idea

that German, Japanese, and Italian expansionism before and during World War II was mainly resource-related. Their domestic deficiencies in fuel and non-fuel minerals led to a quest for control of key foreign sources.<sup>23</sup>

Many U.S. reserves were seriously depleted due to the intensity of World War II and the support requirements of deficient allies. Over the years, import dependence has been increasing, as has the list of minerals strategic and critical to the U.S. economy.<sup>23</sup>

President Eisenhower had a strong concern for mineral availability to the U.S. He substantially increased the national stockpiles and instituted financial supports for domestic producers of strategic minerals. He appointed a minerals policy commission, the Paley Commission, whose findings about strategic and critical minerals still have great applicability today.<sup>23</sup>

Until the current administration, minerals policy has been severely neglected. Presidents have often sold off stockpiles to battle excessive government spending.<sup>23</sup>

In 1973-1974, soaring commodity prices and an oil embargo alerted Americans to the twin dangers of resource exhaustion and dependence on unreliable materials suppliers.

Today, the main areas of concern are: Communist intervention in southern Africa; the world's major source of numerous strategic and critical minerals; the

instability of some governments in southern Africa; and the racial situation in the Republic of South Africa.

#### **SOUTH AFRICA: A STRATEGIC MINERALS BONANZA**

The western world is extremely dependent on the countries of southern Africa for supplies of many strategic minerals. By 1981 figures, Zaire is the world's leading producer of cobalt and industrial diamonds and the world's sixth largest producer of copper. Zambia is the world's second largest producer of cobalt and the world's fifth largest producer of copper. Zimbabwe is a significant world supplier of chromite and ferrochrome, holding the world's second largest reserve base for chromite ore. They also are a significant world supplier of asbestos, natural corundum and lithium. Gabon is the world's fourth largest manganese ore producer. However, the true leader in the production of Western world strategic minerals is the Republic of South Africa.<sup>24</sup>

South Africa is endowed with a large variety of strategic minerals, including chromium, manganese, platinum group metals, vanadium, gold, coal, diamonds, copper, asbestos, nickel, uranium, iron, phosphate rock, antimony, zinc, tin, silver, fluorspar, vermiculite, lead and others.

All of the above minerals may be, to a larger or lesser extent, regarded as minerals of strategic importance to many countries, including the United States.

However, the first four; chromium, manganese, platinum group metals and vanadium are especially crucial to the western economy as they are foundation stones in industrial production and intensively used by many weaponry industries. More importantly, the United States, Japan and the European Economic Community (EEC) perceive excessive import dependence on a potentially unstable supply country, and region, as a major reason for concern.

#### **Growing Strategic Importance**

The strategic importance of these four South Africa minerals for the West is underlined, if one takes into consideration that the other major producers of these minerals are centrally planned economies which are controlled (or at least influenced) by the Soviet Union. For instance, South Africa, together with centrally planned economies produce 70 percent of the world's chromium, 72 percent of the world's manganese, 95 percent of the world's platinum group metals, and 67 percent of the world's vanadium.<sup>25</sup>

Mineral reserves are not finite. They can be exhausted by intensive exploitation. In fact, Europe, the oldest industrialized civilization on earth, illustrates this point; many minerals there have been exploited to such an extent that they cannot be mined economically any more. The United States is also at the stage where more

and more minerals can only be mined subeconomically and the domestic demand has to be satisfied by imports. Thus, dependency on external sources of minerals is steadily increasing in the USA. The Eastern Block, on the other hand, lagging behind the West in its economic development effort has greater mineral resources than the West. Consequently, Eastern Block nations are less dependent on external sources than the western industrialized countries.

Within the context of the East-West conflict and the increasing dependency of many Western countries on external sources of minerals, is the strategic importance of South Africa's minerals diminishing or appreciating? Decreasing South African shares in world mineral markets can be interpreted as diminishing strategic importance. Similarly, increasing South African shares in world mineral markets can be an indicator for appreciating strategic importance. Figures II-1 through II-3 examine changes in the international role of these important South African minerals over the last decade i.e. from 1972 to 1982.

Figure II-1 shows a comparison between the South African share in the Western world mineral production in 1972 against its share in 1982.

According to that Figure II-1, the role of South Africa in the western world mineral production has

increased over the last decade for all of the four investigated minerals. The Republic's share in production of chromium almost doubled over the decade.

From the point of view of strategic importance, South Africa's share of mineral exports should be more important than its share of mineral production. Its share of mineral exports indicates the role of South Africa as a supplier of minerals to the West. Figure II-2 presents a comparison between South Africa's share of western world imports of these minerals in 1972 against its share in 1982.

According to figure II-2 the role of South Africa in the Western World mineral exports has increased over the last decade for all the four minerals. Figure II-2 also reflects the extent to which the South African mining industry has upgraded its mineral outputs by further processing of minerals, for instance, converting chrome ore into ferrochrome and manganese ore into ferromanganese.

The magnitude of reserves can be an indicator for future developments in the role of South Africa both as a supplier and a producer of these four minerals. Figure II-3 shows a comparison between South Africa's share of western world reserves in 1972 against its share in 1982.

According to figure II-3, one can confidently suggest that the South African reserves are still far from

FIGURE II- 1 CHANGES IN SOUTH AFRICA'S ROLE IN WESTERN WORLD SELECTED MINERAL PRODUCTION, 1972 compared to 1982

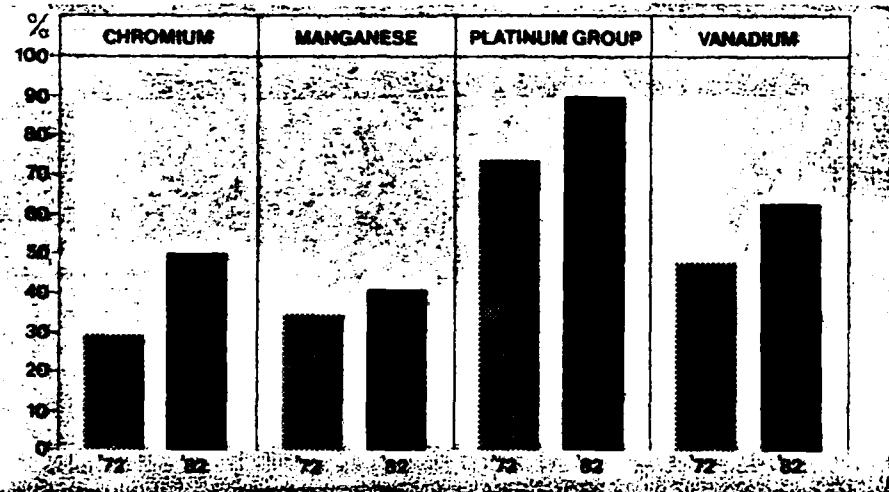


FIGURE II- 2 CHANGES IN SOUTH AFRICA'S ROLE AS A SUPPLIER OF SELECTED MINERALS TO THE WESTERN WORLD, 1971 compared to 1981

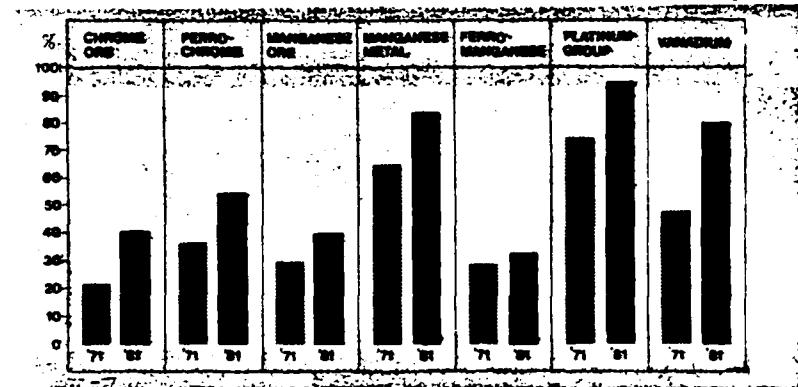
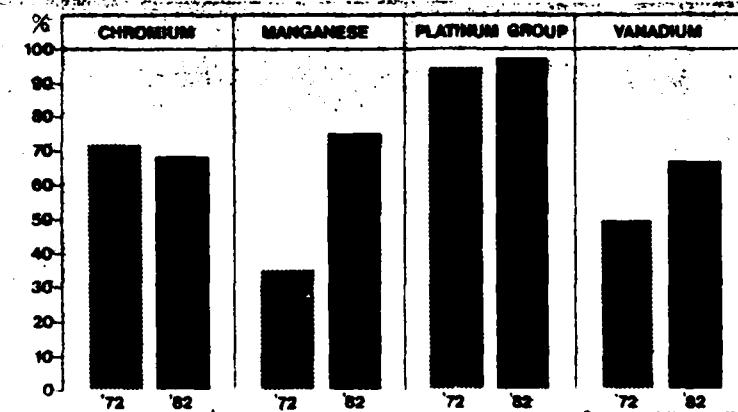


FIGURE II- 3 CHANGES IN SOUTH AFRICA'S SHARE OF THE WESTERN WORLD'S SELECTED MINERAL RESERVES, 1972 compared to 1982



SOURCE: 25

being exhausted. In fact, South Africa's shares of manganese and vanadium of the Western world reserves have significantly increased over the last decade. Only the reserves of chrome decreased slightly. Consequently, it can be inferred that in the next decade the international role of South Africa's minerals will be maintained and may even be enhanced. The Western World is also concerned that regional stability is enhanced, or at least maintained.

#### **South Africa as a Subsaharan Stabilizer**

Although numerous problems exist, it is proper to point out that The Republic of South Africa is a stabilizing factor in southern Africa in several areas.

South Africa has become a substantial exporter of food at reasonable prices. Today its Black African grain customers include: Zambia, Mozambique, Zimbabwe, Zaire, Kenya, Malawi, Angola, the Ivory Coast, Mauritius and Tanzania.<sup>26</sup>

Concerning transportation, South Africa is linked by air, road and especially rail to all neighboring states. About 70 percent of Zambia's rail cargo moves through South Africa, half of this being mineral exports. Zaire imports petroleum products and exports copper through South Africa harbors.

Inter-territorial contract labor agreements represent the oldest form of cooperation in southern

Africa. Presently, the South African economy directly employs 301,700 foreign Blacks from neighboring countries. The amounts sent back to their countries of origin may be in the region of \$300 million in terms of 1980 rates.<sup>26</sup> The advantage of foreign workers employed in South Africa is two-fold: firstly, income earned is freely transferable to their home countries and secondly, skills are acquired during their stay in South Africa which in turn could be put to good use after returning home.

Other areas of stabilization include the distribution of millions of doses of vaccine against 42 different diseases to South Africa's neighbors. The South African Council for Scientific and Industrial Research provides advisory services to other southern Africa nations in the fields of personnel research, adaptability, intelligence tests, mechanical engineering for the mining industry and water research.<sup>26</sup> Speaking of water, since water is a scarce resource in southern Africa, the Republic of South Africa has initiated water and power projects with neighboring states with a view to the best utilization of common rivers and to avoid pollution.

One of the most important stabilizing contributions South Africa makes to southern Africa is trade. At least 50 of the mainland and island independent African states trade with South Africa. South Africa also brags of their cooperative spirit, like recent

negotiations with Zimbabwe over the retention of a preferential trade agreement which is beneficial to Zimbabwe. Along these trade lines, neighboring countries have readily accepted the South Africa Rand monetary system, which facilitates trading stability.

#### **The Coexistence of Destabilizing Factors**

Although destabilization of sub-continent Africa is not in the Republic of South Africa's or the western industrialized countries' best interest, its potential dangers are real, being enhanced by two different catagories of factors. First, there are certain built-in destabilizing factors and, second, there are other externally-imposed influences with a strong destabilizing effect.

#### **Built-In Destabilizing Factors**

Five built-in destabilizing factors<sup>26</sup> in southern Africa can be listed:

1) The rate of population increase of 2.7% per year, which will double the population in 26 years, contributes greatly to the destabilization of the region. This increase has caused an imbalance in the popular demand for education, health services, housing, employment and strains the limited resources of the states.

2) The above contributes to the political instability of several countries in the region. Ethnic diversity and divisions have also very often fueled power

struggles and instability.

3) Traditional systems, such as the communal land tenure system, coupled with the determination of some Black leaders within the region to pursue socialist theory have become serious obstacles to economic progress.

4) Importantly, an attitude of political hostility towards South Africa by its neighboring states contributes to poorer economic performances by those neighbors.

5) Apart from the lack of skills and illiteracy among the region's black population, the lack of an industrial awareness among several African leaders and an unwillingness to acknowledge that true independence entails accepting full responsibility for one's own actions instead of putting the blame for all shortcomings on external factors have retarded development in the sub-continent.

#### **The Special Case of South Africa Racial Tension**

While South Africa is richly endowed in minerals, in fertile farmlands, and in able industrial leaders, its history has conferred upon it one of the world's most intractable social conflicts. South Africa's system of apartheid (apartness), developed and institutionalized largely by the Afrikaans-speaking majority within the white minority, lodges in the hands of the nation's 4.5 million whites virtually all political power and economic

control. South Africa's 23.5 million blacks, Coloureds (persons of mixed race) and Asians may not vote in national elections; they may reside only in areas designated for them by the national government, and though job limitation laws are gradually being relaxed under pressure of a national labor shortage, non-whites are barred from holding many of the nation's executive and white-collar jobs, and even many of the betterpaying blue-collar jobs. Africans must carry identification papers, complete with fingerprints, and be prepared to show these passes to a policeman on demand. Government per capita expenditures for black education, health and housing are only a fraction of the per capita outlays for these services for whites. The lives of non-whites are thus greatly circumscribed by a government they cannot control through the ballot.<sup>27</sup>

Countless books and documentary studies have examined the history and social effects of apartheid, and this thesis will not repeat that material except as it bears on its principal theme. But the issue of apartheid is so pervasive in South Africa and such a major irritant in the nation's international relations that it cannot be ignored.

While social change and the pressures of an expanding economy have opened to blacks many jobs formerly held only by whites, all change stops short of conferring

true political power on nonwhites. Political equality would, in the view of the whites, constitute the first step to converting South Africa to black rule. This is unacceptable to most white South Africans, and emphatically so to the ruling National party.

Because of the rigidities in the system, blacks seeking political power must operate largely outside the framework of law, and many young militants have gravitated to such organizations as the African National Congress and the Pan-Africanist Congress. Both organizations have been suppressed since 1960 and so largely operate from bases outside South Africa to promote change--revolution, in the view of most white South Africans--inside the nation.<sup>27</sup> To an extent, they fill the role that in other countries is played by an elected opposition.

Without a doubt, some of the illegal organizations are financed and encouraged by Moscow, raising the question of what kind of political system they would install if they succeeded in overthrowing the government. However, such an overthrow seems quite remote from the perspective of 1984. With an efficient police force and well-trained and well-equipped armed forces that do not hesitate to cross borders to raid guerrilla camps, the South African government feels confident of its ability to control internal insurrection. "We can deal with anything but an Afghanistan," says a South African official. What

may be more difficult to combat is politically inspired sabotage, such as the simultaneous bomb attacks on two of South Africa's synthetic fuel plants that occurred in 1980.<sup>27</sup>

The South African Institute of Race Relations, a widely respected private organization in Johannesburg just released a 700 page survey on the South Africa racial situation in July 1984.<sup>28</sup> Their findings say the racial situation in South Africa has changed little in the past 50 years. Whites have a low infant mortality rate when compared to blacks. For every dollar earned by a white household an Asian family brings home 59 cents, coloureds 40 cents and blacks 15 cents. In 336 industrial disputes in 1983, nearly a million man-hours were lost. Every 2.5 minutes, a non-white was arrested for violating pass laws that restrict where blacks may travel. Yet another statistic must have given supporters of apartheid cause for alarm: more people died or were injured from acts of sabotage in the first five months of 1983 than in all the six preceding years.<sup>28</sup>

#### **External Destabilizing Factors**

Three externally-imposed factors have a strong destabilizing effect<sup>26</sup>: 1) Soviet expansionism and imperialism; 2) armed conflicts; and 3) western attitudes. A discussion of the threat of Soviet expansionism is presented in this chapter.

Pertaining to the second factor, armed conflicts within the region between Black people of different ethnic origins are causes of tension and instability. Terrorist movements like the ANC (African National Congress) and SWAPO (South West Africa People's Organization) have an effective destabilizing effect on the countries in which they are based. If countries provide facilities for armed terrorists acting against neighboring states, it is not surprising if their own internal opponents think that the use of violence for political ends is condoned.

Western attitudes have not always been helpful in stabilizing the sub-continent. While anxiously demonstrating to Black states that they are on their side in fighting "apartheid" in South Africa, the Western powers have done nothing to promote closer economic ties between Black states of the region and South Africa which would have done more to promote economic progress than handouts of financial aid.

#### **South Africa's Goal: Export Market Growth**

South Africa suffers an imbalance between skilled labor on the one hand and semi-skilled or unskilled labor on the other hand. This problem has received special attention over the last number of years with the result that a totally new manpower strategy is now emerging.<sup>28</sup> This includes: 1) New organizational structures to ensure proper planning; 2) Strong emphasis on training

including financial assistance by the State and fundamental reforms in education systems; and 3) Abrogation of restrictive legislation.

The general picture of South Africa at this moment is one of consultation, economic and political development, peaceful coexistence, constructive developing race relations and confidence in the future. Evolutionary and orderly change is taking place and there is a determination to succeed.

A major factor in this growth compulsion is their very fast expanding population and the need to supply job opportunities to all workseekers. Seen from the viewpoint of the creation of job opportunities, the real gross domestic product must increase by at least 5 percent per annum. A prerequisite for that sort of economic growth is, among many other factors, active participation in international trade and, furthermore, active international participation in the South African economy.

That, then, in plain and simple terms, is the one side of the coin of interdependence. South Africa, and in particular her hundreds of thousands of Black workseekers entering the labor market each year, need full scale economic interaction with the Western World. But then there is the other side of the coin. While it is true that South Africa needs investment, know how, machines and many other items, it is equally true that their trading

partners need commodities vital to their economic well-being and prosperity, which the Republic of South Africa can supply.

With this situation, logic dictates that the various parties which are thus interdependent should positively and actively pursue policies and programs aimed at ensuring continued and expanding co-operation and interaction.

In spite of the logic promoting constructive interdependence, many of South Africa's customers remain concerned about the security of supplies of South African minerals. For this reason, the Minister of Mineral and Energy Affairs, The Hon. F. W. de Klerk, recently issued a clear and unambiguous statement. It reads as follows:

The appropriate mineral strategy for South Africa at this time, taking into account the present hostile international attitude and increasing pressure on South Africa, is not to use our mineral weapon as a threat. Such action can only be effective, and doubtfully so, for short term political gain.

We have over many years built up our present reputation as a reliable supplier and only under extreme provocation where our very existence is threatened, should the mineral weapon be invoked.<sup>28</sup>

In summary, the Government, mining and industrialized powers in the Republic of South Africa certainly do not want any type of disruption of chromium, manganese, platinum group elements, vanadium, or any other strategic minerals market. The consensus is that they

have more to lose than they have to gain.

#### **USSR POSITION AND STRATEGIES FOR CRITICAL MINERALS**

A high degree of self-sufficiency for non-fuel minerals allows the Soviets to follow mineral strategies that appear economically unorthodox. However, their strategies, policies and actions actually pursue communist doctrine quite effectively, at minimal risk and cost.

##### **Soviet Mining Industry Status**

In June 1980, at a major conference on the "resource war," sponsored by the Pittsburgh World Affairs Council, Dr. Daniel I. Fine of the Mining & Minerals Resource Research Institute of MIT, pointed out that the Soviets are rapidly moving from self-sufficiency to import dependency for a number of strategic minerals. The reasons for this transition include Soviet mismanagement in the mining industry, depletion of higher grade ores, stockpiling for military purposes, location of reserves beneath the Siberian permafrost, labor management problems, and rising industrial demand.<sup>4</sup>

Despite domestic mining setbacks, Soviet long term mineral policy is based on self-sufficiency. The historical and ideological importance of this strategy, combined with the crucial role of minerals in industrial development, suggests further pursuit of mineral independence. Unique tactics designed to further this goal include the development of Arctic minerals and the

relegation of prices to secondary importance. Trading often satisfies political rather than economic goals.<sup>1</sup>

Still, the Soviet Union is in an enviable position when compared to the western industrialized countries. Their net import reliance for non-fuel minerals and materials is extremely low (Figure II-4). This gives them enormous freedom of choice in selecting policy options for strategic minerals. In most cases, they are able to follow a national strategy for critical minerals which minimizes risk while magnifying the problems they can cause their enemies.

#### **Soviet Influence on World Mineral Markets**

Testifying before the Senate Committee on Energy & Natural Resources,<sup>30</sup> Dr. Fine explained that the behavior of the Soviet Union in the metals market is to disregard the rules, to pursue national interest, and to weaken the capacity of metals and metallurgical production and security within the West. For example, in 1982, world metal markets collapsed and metal prices reached historic lows. During that period the Soviet Union decided to dump into the world market below cost, 75 million pounds of nickel. This was regardless of the unemployment it has caused in Ontario, Canada, the primary free world producer of nickel. The damage that the Soviet Union inflicted on nickel capacity in the West is yet to be assessed. Even with an economic recovery, it is doubtful that full

FIGURE II- 4

**NET IMPORT RELIANCE: 1983 est.**  
**SELECTED NONFUEL MINERAL MATERIALS**

**U.S.S.R.**

COLUMBIUM	
MICA (SHEET)	2
STRONTIUM	
MANGANESE	
BAUXITE & ALUMINA	48
COBALT	47
TANTALUM	
PLATINUM-GROUP	
CHROMIUM	
NICKEL	
POTASH	
TIN	33
CADMIUM	
ZINC	
ASBESTOS	
BARITE	49
SILVER	10
ANTIMONY	3
VANADIUM	
GYPSUM	
TUNGSTEN	34
IRON ORE	
SELENIUM	
SILICON	
MERCURY	
GOLD	
ALUMINUM	
COPPER	
SULFUR	
IRON & STEEL	13
LEAD	
NITROGEN	
MOLYBDENUM	31

SOURCE: 29

utilization and additional mine financing and exploration will take place as was previously projected in the 1970's before that situation arose.<sup>30</sup>

On the horizon, the potential in the late nineties in nickel is ominous. Cuba will produce 40 to 60 million pounds of nickel per year, and the Soviet Union is adding 272,000 tons of new capacity in its copper/nickel center. Cuba holds 25 percent of the world's laterite nickel reserves and the Soviet Union holds 35 percent of the sulphide nickel reserves in the world. Together, they can begin to mount an offensive against free world competitive nickel production. In the late eighties, Canada, Australia and other nickel producing countries may lose substantial shares of the world nickel market.<sup>30</sup>

In palladium and platinum, the Soviet Union has also penetrated the markets with bizarre behavior. The Soviet Union in palladium alone has restricted supplies to the West at a critical point when Western uses of palladium are increasing, not only as an alternative to platinum itself, but in electronic plating and other areas in the microchip and microprocessor areas. The Soviet Union, by withdrawing supplies as the primary world producer, prompted prices to escalate from \$54 an ounce in June 1982, to as high as \$137 an ounce just 10 months later.<sup>30</sup>

This behavior of the Soviet Union to some is good

business, but the Soviet mining enterprise is not merely business. It is the Soviet national government which owns and develops these scarce resources. Within the last 18 months a strategic materials or metals unit appears to outsiders to have emerged as a primary decisionmaking unit within the Soviet export agencies. Westerners who deal with the Soviet Union are dealing through an intermediary that they cannot identify, but which appears now to have supreme authority on decisions of exports, sales, contracts, and commodity-specific decisions.<sup>30</sup>

#### Soviet Policies for Strategic Minerals

Soviet Major General A.N. Lagovskiy, in a book entitled Strategy and Economics, said the U.S. dependency on certain strategic material imports is the "weak link" in American military capability. Lagovskiy argued for a Soviet effort to control such strategic materials as a means of exerting influence on the health of the American economy.<sup>31</sup>

During a speech in 1960, Nikita Khrushchev discussed the important role Afro-Asian countries must play in limiting economic aggression and dominance by the western industrialized world. Western powers were perceived by the Russians as attempting to gain control of southern Africa's raw material national treasures. Khrushchev postulated Afro-Asian unity as a means of maintaining one's mineral wealth and combatting the West's

aggressive plans.<sup>31</sup>

Leonid Brezhnev is quoted by Robert Moss (editor of the Economist magazine's "Foreign Report") as having told a secret meeting of Warsaw Pact leaders in Prague in 1973 that the USSR's objective was world dominance by the year 1985, and that the control of Europe's sources of energy and raw materials would reduce it to the condition of a hostage to Moscow.... Our aim is to gain control of the two great treasure houses on which the West depends: The energy treasure house of the Persian Gulf and the mineral treasure house of central and southern Africa.<sup>31</sup>

The USSR is well aware of the role of minerals in peace and war (Figure II-5). Joseph Stalin ascribed exceptional significance to the accumulation of state commodity stockpiles. He credited these stockpiles as rendering great help to the Soviet Army and to the economy of the USSR during World War II.<sup>32</sup> Even with the world's most eminent mineral self-sufficiency program, the Soviets still recognize the value of strategic mineral's stockpiling for centrally-planned economies. The status of these stockpiles is a state secret.

#### **Soviet Mineral Denial Strategy**

The Soviet Union and its surrogate -- Cubans and East Germans most prominently -- are dispersed throughout the world and especially in and around central and southern Africa where U.S. mineral dependence is significant. Senator James A. McClure, Chairman of the U.S. Senate Committee on Energy & Natural Resources warns;

FIGURE II- 5  
1948 SOVIET CHEMISTRY TEXTBOOK ILLUSTRATION:  
THE NATIONAL IMPORTANCE OF MINERAL RESOURCES



Химические элементы в земной коре.

SOURCE: 33

Let there be no doubt about their objective in being there. That objective is one that seeks to develop a viable strategic mineral denial strategy, either through physical disruption, market manipulation,<sup>30</sup> or domination of producer or neighboring states.

As postulated by Szuprowicz, a strategic minerals supercartel would be a certainty if the Soviets were able to gain control over southern Africa mineral reserves.<sup>34</sup> Table II-2 shows what an imposing position the Soviet Union would then hold for the world's strategic mineral reserves. Obviously, their dominance of reserve capacities could adversely influence the consumer markets in the United States, Japan, and the EEC.

#### **Soviet Troops in Africa**

The presence of over 30,000 Cuban troops in Angola threatens the stability of that region and is the primary stumbling block to resolving the Namibia independence issue. Altogether, 47,000 Cuban soldiers are stationed in 17 African countries.<sup>12</sup> They are moved around Africa wherever they are needed. State Department Ambassador-at-Large, Vernon A. Walters, in testifying before McClure's committee on May 19, 1983, stated,

someone once said that Cuba is now the largest country in the world. The bureaucracy is in Havana, the government is in Moscow, the army is in Africa and the population is in Florida....<sup>30</sup>

#### **Merchant Ship & Naval Buildup**

The U.S. Secretary of Defense's 1981 publication Soviet Military Power states that the Soviets are seeking

TABLE II-2  
THE ROLE OF SOUTHERN AFRICA\* AND COMECON COUNTRIES\*\*  
IN WORLD MINERAL RESERVES, 1982

Mineral commodity	Southern Africa Rank	%	COMECON Rank	%	SA & COMECON Rank	%
Platinum Group Metals	1	79	2	15	1	94
Manganese	1	80	2	14	1	94
Vanadium	1	53	2	28	1	81
Chromium	1	74	5	<1	1	75
Gold	1	51	2	20	1	70
Alumino-silicates	1	38	2	20	1	58
Iron ore	6	4	1	42	1	45
Fluorspar	1	35	8	4	1	39
Coal	4	10	1	26	1	36
Asbestos	3	6	2	30	1	36
Diamonds	2	30	5	5	2	35
Zirconium	3	17	4	14	2	31
Phosphate	4	6	2	20	2	26
Nickel	5	9	2	16	1	25
Lead	5	4	1	19	1	23
Uranium***	2	21	na	na	na	na
Zinc	5	5	3	13	3	19
Titanium	4	14	7	2	4	17
Antimony	3	7	2	10	2	17

NOTES: \* Includes Bophuthatswana, Ciskei, South West Africa/Nambia, Transkei and Venda

\*\* Includes Bulgaria, Cuba, Czechoslovakia, East Germany, Hungary, Mongolia, Poland, Romania, USSR and Vietnam

\*\*\* Western World only

na Not available

SOURCE: 36

to develop a viable oil and strategic minerals denial strategy, either through physical disruption, market manipulation, or domination of producing or neighboring states. Soviet statements clearly reflects the USSR's understanding of the extent to which the United States and Western Europe currently depend on imports of vital strategic materials from the developing regions. By undermining Western ties with the oil and raw materials producers and exacerbating differences in the Western Alliance over policies toward these regions, the Soviets seek to erode both the economic health and political cohesion of the West.<sup>35</sup> A blue water navy and an expanded merchant marine (Fig. II-6) contribute to Soviet capabilities.

In recent years, the Soviet merchant marine, fishing fleet, maritime research teams, and Soviet Navy have all persistently expanded their operations in Africa. The military purpose of these expanded operations was pointed out by Admiral of the Fleet Gorshkov in 1976 when he postulated that the strengthening of Soviet Naval might around southern Africa depends on the developing of all naval components.<sup>33</sup>

The Soviets put great stress on courtesy visits to African ports by the Soviet fleet. In their view, the visits demonstrate Soviet ideology, way of life, culture and, particularly, technology and naval power.<sup>35</sup>

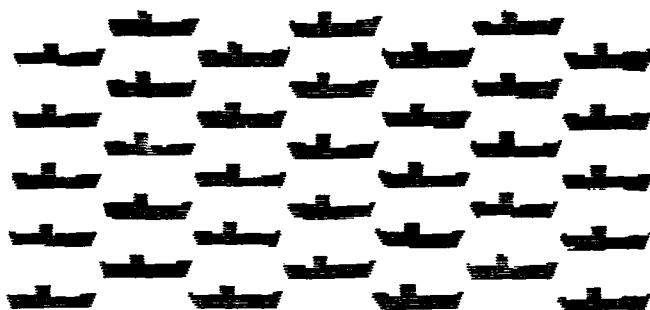
FIGURE II-6  
U.S.A. - U.S.S.R. MERCHANT SHIP COMPARISON

## MERCHANT SHIPS

 = 100 SHIPS

1950

U.S.A.



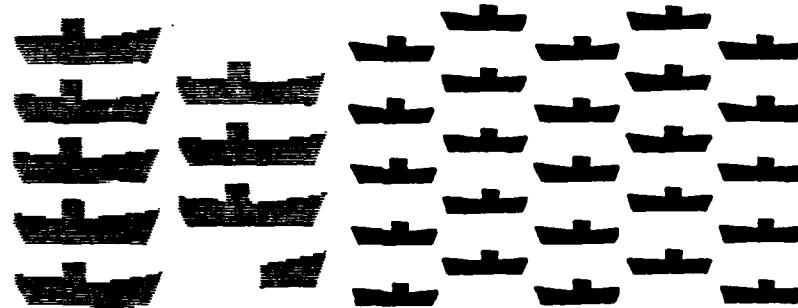
37.4 MILLION TONS

U.S.S.R.



1.8 MILLION TONS

1983



24.4 MILLION TONS

22.4 MILLION TONS

SOURCE: 33

This discussion of the strategies the Soviet Union employs in an attempt to deny the U.S. and her allies of critical and strategic minerals has been presented in the work of Phillip Ballinger.<sup>1</sup> This author agrees with the general conclusion of that work in that the Soviets have a very keen interest in obtaining strategic minerals for themselves and making it difficult for western industrialized countries to secure supplies of critical and strategic minerals.

#### **U.S. POSITION AND RESPONSE TO SOVIET STRATEGIES**

Concerning the U.S. position, this author will discuss: U.S. net import reliance for strategic minerals; the perceived existence of import vulnerability for the U.S.; U.S. insecurity caused by this import reliance; and racial tension as a key factor fo that insecurity. Under U.S. response to Soviet strategies, this author will discuss: The U.S. emphasis on national strategic minerals stockpiling as a key counter-strategy; and current U.S. strategic minerals policy.

##### **Net Import Reliance for Strategic Minerals**

The Western industrialized world's net import reliance for many of the key minerals to basic industry and defense applications is extremely high. Figure II-7 shows the net import reliance the United States has for selected nonfuel minerals and our major sources of supply. We are heavily import dependent for numerous

FIGURE II-7

**NET IMPORT RELIANCE: 1983  
SELECTED NONFUEL MINERAL MATERIALS**

**U.S.A.**

	MAJOR SOURCES 1979-1982	
COLUMBIUM	100	Brazil, Canada, Thailand
MICA (SHEET)	100	India, Brazil, Belgium
STRONTIUM	100	Mexico
MANGANESE	99	So. Africa, France, Australia, Gabon
BAUXITE & ALUMINA	98	Australia, Jamaica, Guinea, Surinam
COBALT	97	Zaire, Zambia, Canada, Belg.-Lux., Japan
TANTALUM	97	Thailand, Canada, Malaysia, Brazil
PLATINUM-GROUP	94	So. Africa, USSR, UK
CHROMIUM	77	So. Africa, USSR, Phil., Zimb., Yugo.
NICKEL	77	Canada, Australia, Norway, Botswana
POTASH	76	Canada, Israel
TIN	72	Malaysia, Thailand, Bolivia, Indonesia
CADMIUM	69	Canada, Australia, Mexico, Korea
ZINC	68	Canada, Peru, Mexico, Australia
ASBESTOS	65	Canada, So. Africa
BARITE	64	China, Peru, Chile, Morocco
SILVER	61	Canada, Mexico, Peru, UK
ANTIMONY	52	So. Africa, Bolivia, China, France
VANADIUM	52	So. Africa, Canada, Finland
GYPSUM	50	Canada, Mexico, Spain
TUNGSTEN	39	Canada, Bolivia, China
IRON ORE	37	Canada, Venezuela, Brazil, Liberia
SELENIUM	37	Canada, Japan, UK, Belg.-Lux.
SILICON	30	Canada, Brazil, Norway, Venezuela
MERCURY	25	Japan, Spain, Canada, Italy
GOLD	21	Canada, Switzerland, USSR
ALUMINUM	18	Canada, Ghana, Venezuela, Japan
COPPER	17	Chile, Canada, Peru, Zambia
SULFUR	18	Canada, Mexico
IRON & STEEL	13	Europe, Japan, Canada
LEAD	11	Canada, Mexico, Australia, Peru
NITROGEN	11	Canada, Trinidad & Tobago, USSR, Mexico

NOTE: Chromium and platinum net import reliance historically exceed 90%. Low figures here reflect low recession demand augmented by recycling's temporary, increased market share.

SOURCE: 29

minerals, a factor in their strategic and critical nature. In addition, assessment of our strategic vulnerability must consider not only our position but also that of our allies, which are even more dependent on imports for many strategic materials (Figure II-8). Compare these depressing import dependence figures with the "freedom of choice" options available to the Soviet Union (Figure II-4).

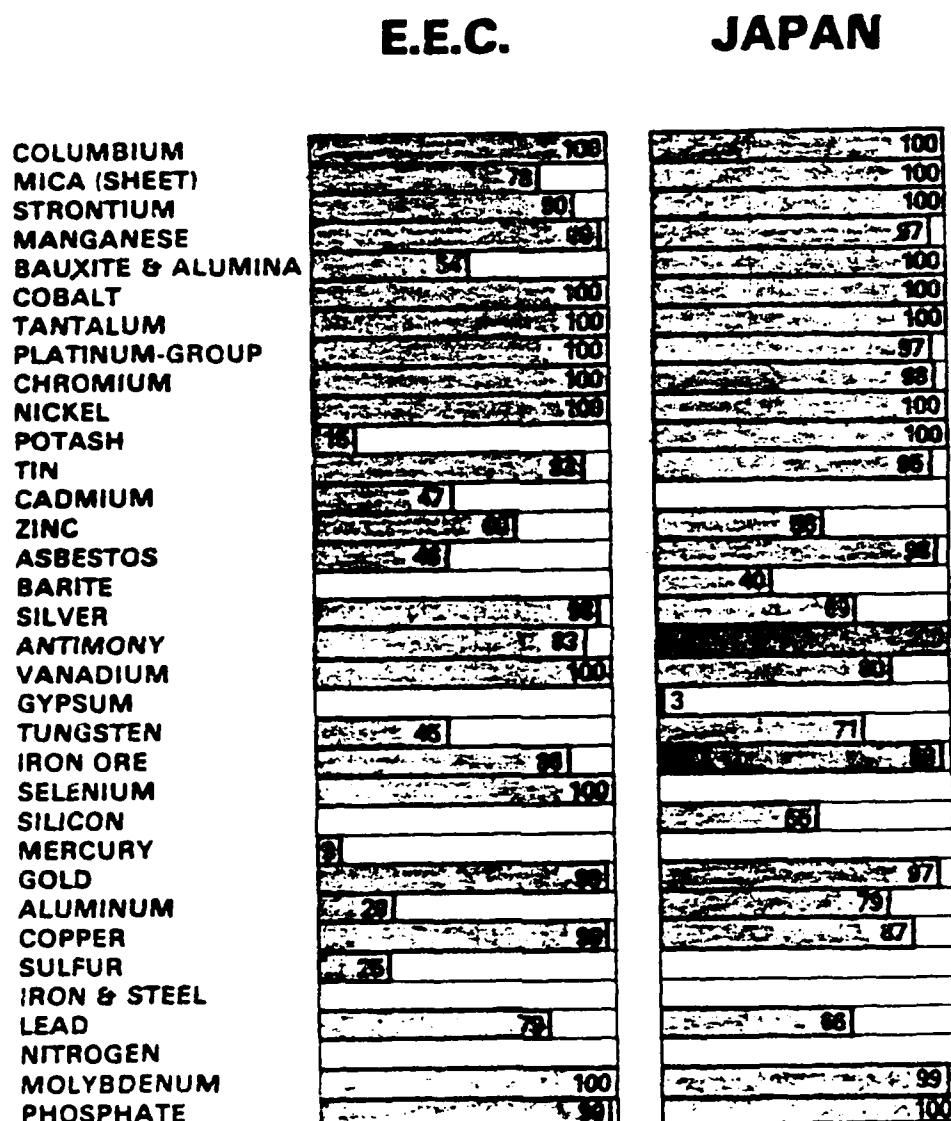
#### **Perceived Existence of Import Vulnerability**

Not just import dependence, but also the degree of vulnerability to supply disruptions must be weighed. Note in Figure II-7 that Canada is a major supplier of many materials, thus reducing the risks of ocean shipments in wartime. Note, also, the minerals where U.S. desires for secure supply may be questionable. USSR and southern Africa suppliers seem potentially tenuous. They are major suppliers of manganese, cobalt, platinum group metals, chromium and others. It follows that these four minerals are considered the most critical and strategic by U.S. standards.

Most metals and minerals are international commodities in that only a few cents per pound can move them physically in the major markets of the world. Politico-economic developments anywhere in the world are likely to have almost immediate effects upon both producers and consumers of mineral materials wherever they

FIGURE II- 8

**NET IMPORT RELIANCE: 1982**  
**SELECTED NONFUEL MINERAL MATERIALS**



SOURCE: 29

may be located. World markets for both mineral raw materials and manufactured articles are becoming more competitive. Minerals producers desire to realize the value added by manufacture. Future imports are likely to include more of the costly upgraded forms, while domestic mineral processing industries face lowered rates of operation.

Not only import reliance, but especially raw material import vulnerability for defense items and necessary industrial production is considered critical. U.S. mineral policy must balance this vulnerability with actions or contingency plans. Materials on hand in strategic stockpiles, other government stocks and industry stocks are our #1 defense against import vulnerability. Other measures like; substitution, recycling, supply diversification, domestic production and processing, materials R&D, educational incentives, foreign policy initiatives, plus many others must all be considered in combating our perceived vulnerability.

#### **Insecurity Caused by Import Reliance**

Numerous, recent, U.S. Senate and House of Representatives committee reports are referenced throughout this thesis dealing with our strategic minerals import vulnerability. Although all actions have not proved positive, more legislation concerning strategic minerals has been passed in the last four years than in previous

United States' history altogether. Throughout all the discussions, an overriding theme exists, FEAR! Legislators and industrial leaders agree that the United States must take positive measures to insure strategic minerals availability. Strategic mineral imports from the Republic of South Africa and other southern African producers are of primary concern. Being the pre-eminent free world superpower and extremely import-dependent for strategic minerals, the United States can ill afford a laisse faire attitude towards the Republic of South Africa. Fortunately, this is not the case. Since the oil embargoes of 1973 and 1979, the United States has displayed almost a paranoiac concern about supply disruptions, with strategic minerals being one of the key areas of concern. Of course, disagreement exists as to which measures are the appropriate ones.

Indeed, agreement does exist among experts in the United States that our imported mineral dependence on the Republic of South Africa does warrant closer attention. The fear of supply disruption exists, whether it is due to Soviet intervention in the region, racial problems in South Africa, excessive import dependence, or a combination of these and other factors.

#### **Racial Tension as a Factor of Insecurity**

The racial situation proves a strong dividing factor among United States citizens. People's memory of

1960's race riots in the U.S. make this a key issue, especially for the majority of our population which is uninformed about strategic mineral import dependence. They see the Republic of South Africa soon facing extreme racial problems much as those through which the U.S. suffered.

#### **Emphasis on National Stockpile Counter-Strategy**

Just 5 years ago, highly industrialized countries like Japan, West Germany, Great Britain, and all other EEC countries had no national stockpiling programs for strategic and critical minerals. France and the United States were the only exceptions, with the French stockpile proving very meager, while the United States stockpile had deteriorated and vast quantities sold off during the preceding two decades.<sup>37</sup> In just 3 years, all those countries and other industrialized nations have realized the need to establish national stockpiles of minerals they deem critical and strategic (Table II-3). These allies see stockpiling as the most economical defense against short-term supply disruptions.

The stockpiles materialized or improved as all these countries saw deterioration of their security of supplies. Comparing Table II-3 with Figures II-2 and II-3, note the many stockpiled minerals and materials where southern Africa, particularly the Republic of South Africa, has dominant reserve capacities and production.

TABLE II-3  
FOREIGN GOVERNMENT'S STOCKPILE POLICIES  
ACTUAL AND PROPOSED

<u>Country</u>	<u>Type Stocks</u>	<u>Materials Stockpiled</u>
Sweden	govt.	chrome ore, cobalt, manganese ore, vanadium, other unspecified.
	private	not available.
Switzerland	compulsory voluntary	essential critical imports. iron, steel, nonferrous metals.
France	semi-govt.	aluminum, chrome, ferrochrome, cobalt, copper, iron ore, lead, manganese, nickel, phosphate rock, titanium, tungsten, zinc, zirconium.
Japan	semi-govt.	aluminum, chromium, copper, nickel, zinc.
West Germany	considered, not established	asbestos, chrome, cobalt, manganese, vanadium.
Spain	considered, not established	aluminum, chrome, copper, manganese, nickel, tin, titanium.
U.K.	govt.	cobalt, ferrochromium, ferromanganese, vanadium, base metals.

Source: 29

They include chrome, cobalt, manganese, vanadium, ferrochrome and ferromanganese.

#### **Current U.S. Strategic Minerals Policy**

National policy with respect to strategic and critical materials is established primarily by two major acts: The Defense Production Act of 1950, as amended, (64 Stat. 798, 50 U.S.C. App. 2061 et seq.), and the Strategic and Critical Materials Stock Piling Act (93 Stat. 319, 50 U.S.C. 98). These have been recently augmented by presidential emphasis program plans.

The Defense Production Act establishes the policy that diversion of certain materials and facilities from civilian to military-related use is required during national emergency mobilization efforts. It also requires the development of preparedness programs to expand productive capacity and supply during these emergencies. These programs are required to reduce the time required for full mobilization in the event of an attack on the United States. Domestic mineral and energy potential must reach maximum productivity if actions occur outside the U.S. which could result in the termination or reduction of strategic and critical materials.<sup>38</sup>

In the Stockpiling Act, the Congress found the U.S. deficient in certain strategic and critical materials to supply the military, industrial, and essential civilian needs for the national defense. The purpose of the Act is

to provide for the acquisition and retention of stocks of certain critical materials. Conservation and domestic supply development are also goals to decrease and to preclude, when possible, a dangerous and costly U.S. dependence on foreign sources of supply during national emergency.

The Stockpiling Act states it is not to be used for economic or budgetary purposes. The quantities stockpiled should be sufficient to sustain the United States for a period of not less than 3 years.<sup>39</sup>

Additional re-enforcing policy statements dealing with materials and the national security are provided by the National Materials and Minerals Policy, Research and Development Act of 1980 (94 Stat. 2305; 39 U.S.C. 1601 et seq.), by the Mining and Minerals Policy Act of 1970 (84 Stat. 1876; 30 U.S.C. 21a) and by many other more narrowly focused laws.

On 5 April 1982, President Reagan transmitted to the Congress his National Materials and Minerals Program Plan and Report to the Congress as a methodology for implementing the National Materials and Minerals Policy, Research and Development Act of 1980. His letter of transmittal stated:

This national minerals policy recognizes: the critical role of minerals to our economy, national defense, and standard of living; the vast, unknown and untapped mineral wealth of America and the need to keep the public's land open to appropriate

mineral exploration and development; the critical role of government in alerting the nation to minerals issues and in ensuring that national decision-makers take into account the impact of their decisions on minerals policy; and the need for long-term, high potential payoff research activity of wide generic application to improve and augment domestically available materials," and "This policy is responsive to America's need for measures to diminish minerals vulnerability by allowing private enterprise to preserve and expand our minerals and materials economy.<sup>40</sup>

The president goes into further detail on how minerals policy must promote decreased vulnerability to insure national security, a vigorous economy, and create American jobs while still protecting the environment. The plan enumerated several major areas of action including: increased availability of lands for exploration, development, and multiple-use; reform of excessively burdensome or unnecessary regulations and statutes; increased stockpiling, including use of exchanges and barter and ensuring the quality of the stockpile; encouraging private sector materials research and development, stimulating coordination between industry and government in technical innovation, and focussing government-financed research and development on long-term, high-risk technology with the best chance for wide generic application to materials problems; and improved minerals and materials information collection, analysis, and dissemination.<sup>40</sup>

The report further stated that it is  
...the position of this Administration that

national materials policy will be coordinated through the Cabinet Council on Natural Resources and Environment. This will ensure high level consideration of important materials policy issues on a timely basis with the capability<sup>40</sup> of prompt action on such issues by the President.

The results of this presidential initiative is addressed in the final chapter.

#### **RESOURCE WAR INEVITABILITY**

This author is indebted to, and gratefully acknowledges, Dr. Paul Anaejionu for his help in formulating the ideas presented in this section on the inevitability of a resource war between centrally planned economies and western industrialized countries.

In conclusion, whether the term is used or not, a worldwide resource war does exist for strategic materials. A resource war satisfies the goals of the participants on all sides. Soviet ideology of expansionism and imperialism are facilitated by a quest for strategic mineral control in and around southern Africa. Producing countries, like the Republic of South Africa, gain bargaining power with their primary customers, the U.S., Europe, and Japan, as consuming countries must be willing to make concessions to insure supply disruptions do not occur. These concessions would make it difficult for the United Nations to impose sanctions against South Africa exports despite racial flair-ups. South Africa's ability to expand the strategic minerals and metals markets over the past decade may also be partially attributed to the

co-operation of these dependent nations. Import dependent consuming countries of strategic minerals, like the U.S., West Germany, and Japan, gain leverage domestically by using a "resource war" doctrine so that their goal of greater strategic mineral independence receives "national priority" attention. Either conservatives or liberals can use this priority attention to their advantage by postulating policy options that are self-serving to their cause. These policy options for the United States are discussed in detail later.

A resource war is inevitable, the key players in the strategic minerals market want it to exist. The term, "resource war", lends attention to the cause, which in this case, is justified. With import dependence exceeding 50 percent for over 19 minerals, (Figure III-7) plus their processed forms, the United States must take more steps to decrease vulnerability. The trends of the past decade need to be reversed.<sup>41</sup>

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## CHAPTER III

### WORLD AND U.S. CHROMIUM MARKET PROFILE

#### INTRODUCTION

The next four chapters attempt to analyze an individual commodity, chromium, and those factors that influence the security of chromium supply for the U.S. military-industrial complex. This is one way that viable policy options can be developed. It is meaningless to discuss U.S. nonfuel mineral policy without looking at individual commodities.

#### THE GEOLOGY OF CHROMITE

Chromite deposits occur in large, layered, stratiform bodies or smaller, lenticular, podiform-type deposits. Stratiform deposits are only economically significant in the Bushveld Complex of northeastern South Africa and in the Great Dyke seam of Zimbabwe.<sup>1</sup> That is where approximately 95% of world reserves are concentrated. The Stillwater Complex in Montana is an example of a stratiform deposit that is presently uneconomical to develop. Stratiform deposits are usually several feet thick, of uniform composition, and extend over large areas.<sup>1</sup>

In contrast, significantly smaller podiform deposits occur in other major reserve areas of the world. Chromite derived from podiform formations tends to be hard, lumpy ore, and is valued for its ease of smelting

into ferrochromium. Podiform chromite is found in the Ural Mountains of the Soviet Union, Turkey, Albania, the Philippines, Brazil, Iran, Finland, Greece, Cyprus and western Pakistan.<sup>2</sup>

Table III-1 provides a list of the significant characteristics of the major, economic, chromite deposits of the world.

#### **RESERVES AND RESOURCES OF CHROMITE**

World reserves of chromite, estimated at about 3.7 billion short tons in 1980, are quite large relative to current chromite production. The ratio of reserves to production suggests that the world chromite supplies should be sufficient well into the next century. However, reserves are overwhelmingly concentrated in two countries, South Africa and Zimbabwe. Estimates of the percentage of total reserves located in these two countries range from about 88 percent to over 95 percent, clearly indicating that this region will continue to be the preeminent source of chromite ore. As can be seen in Table III-2, the United States has no significant chromite deposits which can be recovered economically at this time.

#### **WORLDWIDE PRODUCTION**

World production of chromite ore and ferrochromium is provided in Tables III-3 & III-4 in weight of contained chromium, showing what a large percentage of ore is processed by the nation that mined it.

TABLE III-1  
MAJOR CHROMITE DEPOSITS, BY COUNTRY

Republic of South Africa - The Bushveld Complex

Characteristics:

1. Stratiform
2. Several feet thick
3. Uniform composition
4. 10 to 40 degree dip
5. Laterally very extensive
6. High iron %

Zimbabwe - The Great Dyke

Characteristics:

1. Stratiform
2. 2 to 18 inches thick, average = 7 inches
3. Uniform composition
4. 15 to 50 degree dip
5. Laterally very extensive
6. Higher grade than Bushveld

U.S.S.R.

Characteristics:

1. Both stratiform & podiform
2. Podiform deposits are smaller, lenticular and typically occur in the Ural Mountains.
3. Reserves may be grossly underestimated.

Albania, Brazil, Finland, Philippines, Turkey,  
Zimbabwe

Characteristics:

1. Podiform deposits
2. High grade, but not extensive
3. No economies of scale

SOURCE: 1

TABLE III-2  
WORLD CHROMITE RESERVES AND RESOURCES  
(Million short tons, gross weight)

	<u>Reserves</u>	<u>Other Resources</u>	<u>TOTAL</u>	<u>Type</u>
<b>Western Hemisphere:</b>				
United States	--	11	11	High iron
Brazil	2	22	24	High iron
Canada	--	11	11	High iron
Cuba	3	11	14	High iron
Greenland	--	11	11	High iron
<b>Eastern Hemisphere:</b>				
Albania	2	17	19	High chrom.
Finland	28	55	83	High iron
India	6	28	34	High chrom.
Iran	2	11	13	High chrom.
Madagascar	2	11	13	High chrom.
Philippines	3	22	25	High alum.
South Africa	2500	22000	24500	High iron
Turkey	6	22	28	High chrom.
USSR	17	100	117	High chrom.
Zimbabwe	1100	10000	11000	High chrom.
<b>WORLD TOTAL</b>	<b>3700</b>	<b>32000</b>	<b>36000</b>	

\*Predominant type of ore in country.

Source: 3

TABLE III-3  
WORLD CHROMITE MINE PRODUCTION  
1981, AND CAPACITY, 1981 and 1985  
(Thousand short tons of contained Chromium)

	<u>Production</u> <u>1981</u>	<u>Capacity<sup>e</sup></u> <u>1981</u>	<u>1985</u>
South Africa	946	1500	1800
USSR	925	1000	1000
Turkey	165	170	180
Albania	150	300	300
Zimbabwe	139	325	350
Philippines	127	150	180
Brazil	106	130	150
Finland	107	130	140
India	80	170	200
Others	71	125	300
World Total	2816	4000	4600

<sup>e</sup>Estimated

Source: 4

TABLE III-4  
WORLD FERROCHROMIUM PRODUCTION,  
1981, AND CAPACITY, 1981 and 1985  
(Thousand short tons of contained Chromium)

	<u>Production</u> <u>1981</u>	<u>Capacity<sup>e</sup></u> <u>1981</u>	<u>1985</u>
South Africa	490	540	520
USSR	418	420	420
Japan	202	370	370
Zimbabwe	165	200	200
Sweden	136	170	170
United States	128	220	200
Brazil	81	90	90
China	58	60	60
Yugoslavia	48	60	60
Finland	34	40	40
West Germany	32	80	80
Poland	32	40	40
India	23	30	90
Others	108	280	360
World Total	1955	2600	2700

<sup>e</sup>Estimated

Source: 4

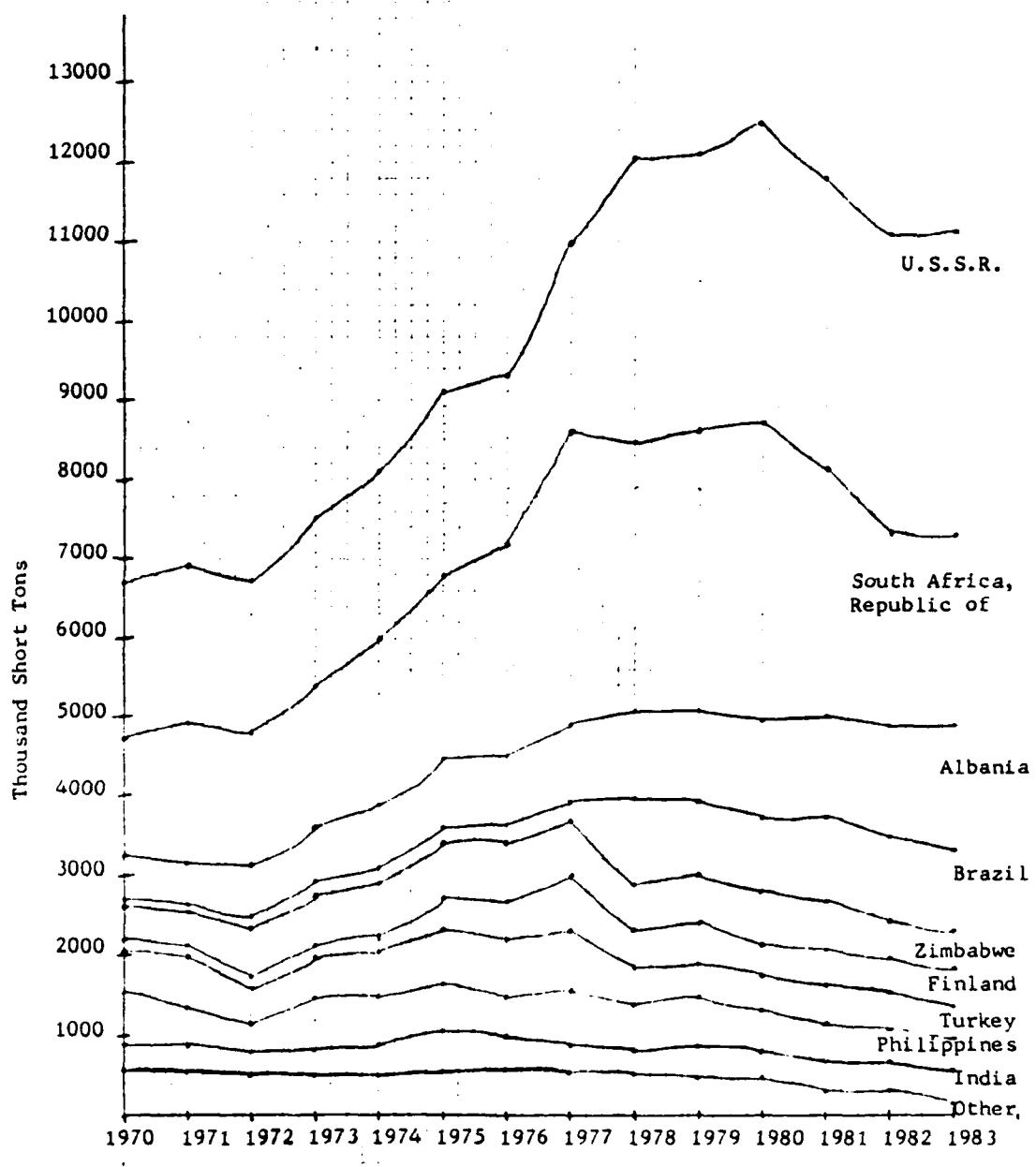
### Chromite Production

World chromite ore production is not nearly as concentrated as are reserves. South Africa and the USSR are by far the largest chromite producers, accounting for an estimated 31 percent and 26 percent of world production respectively, in 1981. Chromite ore is also produced in nearly 20 other countries in most regions of the world. Other leading ore producers in 1981 were Albania (12 percent), Zimbabwe (6 percent), the Philippines (5 percent), Finland (4 percent), Brazil (4 percent), Turkey (4 percent) and India (4 percent).<sup>5</sup>

Over the last twenty years, world chromite output increased at a annual trend rate of about 3.8 percent (Figure III-1). The overwhelming portion of that growth was registered by South Africa. In recent years, Brazil has also shown a significant expansion of chromite output. Among the centrally planned economies, it is estimated that Albania, the USSR and Cuba have all experienced substantial growth in chromite production over the past two decades.

World chromite mining capacity has recently been estimated at about 13 million short tons per year. As this figure is well above present world mine output, adequate capacity would seem to be assured over the next 5-10 years. The longer-run outlook for expansion of chromium mining capacity is also optimistic. World

FIGURE III- 1  
Chromite: World Production, by Country



SOURCE: 5

capacity expansion is not constrained by reserves, and experts believe that there are adequate financial resources and infrastructure support for future capacity expansion. Presumably, this assessment assumes a favorable climate for investment in southern Africa and elsewhere.

Despite apparent excess capacity, a good deal of exploration and mining investment is planned or underway. Specific projects for development of new chromite mining or processing capacity and/or delineation of additional ore reserves have been reported for Brazil, Greece, the Philippines, Sudan, Finland, India, Madagascar, Papua New Guinea, and Pakistan. With the wide dispersion of chromite reserves and the large number of small open pit mines, it is thought that many ore-producing countries could increase chromite output by 50 to 100 percent in as little as two years, if necessary.<sup>4</sup>

Table III-3 shows the 1981 chromite mine production for the major producers, as well as their estimated expansion capacity. This expansion may be delayed several years due to depressed markets during the recent worldwide recession. Note that the United States, and all of North America, is excluded from Table III-3, as they have mined no chromite in the past twenty years.

#### Ferrochrome Production

Reported world ferrochromium production in 1981

came from 26 countries. Ferrochromium production and capacity are shown in Table III-4. The major producers are the Republic of South Africa and the USSR, Japan, and Zimbabwe. Together, the Republic of South Africa and the USSR accounted for 46% of world production in 1981. The Republic of south Africa and Zimbabwe accounted for 34% of world production. The changing ferrochromium supply pattern is shown by the relation of actual production to rated capacity and the changing rated capacities. The Republic of South Africa, Zimbabwe, the Philippines, and India are chromite producers and were producing ferrochromium at near capacity in 1981. The United States, Japan, and European nations, traditional ferrochromium producers, were operating well below capacity in 1981. New capacity is planned or under construction in Greece, Turkey, India, and the Philippines, all of which are chromite producers.<sup>4</sup>

#### **UNITED STATES' CHROMIUM PRODUCTION AND POTENTIAL**

From 1900 to 1961, the United States mined domestic chromite resources, therefore, a secure potential supply source does exist, to a limited extent.

##### **Domestic Chromite Potential**

Domestic chromite resources are quite sparse and do not represent a substantial long-run supply alternative. Indeed, the chromite resources of the United States are not only quite small, but of low grade compared

to most ores that reach the world market. Although chromite was mined in the United States until 1961, since 1900 annual production was significant only in years when it was heavily subsidized by the government. This domestic production ceased in 1961 with the termination of the last Defense Product Act contract, and with the government termination of stockpile purchasing program. Since then, domestic consuming industries have been dependent on imports and, before 1978, releases of "excess" material from the government stockpile. Even during emergency war years, domestic production satisfied only a small percentage of demand.

Scattered information on the domestic costs of producing chromium suggests that a price of approximately \$800 per metric ton of contained chromium might be sufficient incentive for domestic production to reach the peak rates achieved during the subsidized government stockpiling program of the 1950's, about 40,000 short tons of contained chromium per year, or about 7 percent of normal U.S. consumption.<sup>6</sup> Current prices are approximately \$110 per metric ton of Turkish chromite and \$52 per metric ton of South African chromite (lower grade).<sup>5</sup>

Although chromite prices may be temporarily high enough to justify exploitation of poor domestic resources during a severe foreign supply disruption, it is highly

unlikely that prices would stay high enough for a long time to justify the substantial fixed investments required. The capital for mining, processing, and transporting chromite is very durable and requires long lead times to bring onstream. There would be a great risk for investors that the chromite price would drop long before the benefits of these investments justified their acquisition costs.

Domestic chromite resources exist in Alaska, California, Montana, Oregon, Washington and the Appalachian region. The Stillwater Complex in Montana contains an estimated 76 percent of the U.S. resource base.<sup>7</sup> Oregon beach sands are next in importance. Due to their small ore body size, low ore grade, or considerable distance from processing plants, U.S. chromite resources are not economic to produce. Rail transportation costs, in particular, are very high: if production took place at the Stillwater Complex, they would constitute roughly 40 percent of the estimated delivered price at the industrial areas where the chromite could be processed and used.<sup>7</sup>

#### **Domestic Ferrochrome Production**

The submerged arc electric smelting furnace (SAF) is used primarily for the production of various chromium, manganese and silicon ferroalloys and metals in the United States. The SAF process dates back to the turn of the

century when ferrochrome was first offered to the steel industry. Today, only the SAF process is used to produce ferroalloys because of the high temperatures attainable only by an electric arc.<sup>8</sup> Table III-5 summarizes the present status of installed SAF capacity for ferrochrome.

TABLE III-5

U.S. INSTALLED SAF CAPACITY<sup>8</sup>

<u>Product Normally Produced</u>	<u># of SAF's</u>	<u>Size Range of SAF's in MW</u>	<u>Total MW Capacity</u>	<u>Capacity 000 S.T. Product</u>
		<u>0-10</u>	<u>10-20</u>	<u>OV20</u>
HCFeCr	10	6	2	2
FeCrSi	4	2	1	1
				180
				53
				265
				58

SOURCE: 8

One of the most promising processes on the horizon for ferrochrome production is the application of plasma arc technology for smelting. At this point, the process is highly experimental. While industries in Germany, Belgium, Sweden and Japan are experimenting with plasma arc technology, only South Africa is close to commissioning a pilot furnace.<sup>9</sup> United States ferrochrome producers have made little progress in this area, although Westinghouse is evaluating the technology's potential for blast furnaces.<sup>10</sup>

Over the years, the U.S. ferroalloy industry has continually upgraded its efficiency and has replaced many small furnaces with larger and more modern units. Even most of the small furnaces (0-10 MW) listed in the above

table have been modernized and are efficient production units.

But capacity to produce ferrochrome and actual operation are two very different beasts. At the end of 1983, Globe Metallurgical, a subsidiary of Interlake Inc. of Berwery, Ohio was the only U.S. producer of ferrochromium in operation.<sup>11</sup> They were producing limited quantities of high-carbon ferrochromium and speciality alloys (e.g. low-carbon ferrochromium).

In the spring of 1984, they stopped operations, and domestic capacity utilization dropped to zero for high-carbon ferrochrome.

However, on December 30, 1983, the Macalloy Corp. of Charleston, South Carolina, was awarded a one year contract by the federal government's General Services Administration (GSA) to upgrade 121,000 short tons of stockpiled chromite to high-carbon ferrochrome. This stockpile conversion is addressed later. According to the GSA, this contract will enable Macalloy to reactivate one of its two furnaces for a full year, and will increase domestic capacity utilization from 0 to 20 percent for HCFeCr.<sup>12</sup> That sounds like quite an increase for one furnace.

#### UNITED STATES' CRITICAL & STRATEGIC END USES FOR CHROMIUM

Chromium is an indispensable mineral, critical to the maintenance of high quality performance standards in

the domestic production of stainless steel, tool steels, alloy steels, nickel-based and cobalt-based superalloys. These items are used to make the basic products listed in Table III-6.

More specifically, Table III-7 lists the top 32 industrial uses of chromium in 1979 and Table III-8 includes smaller defense-related uses, also. These 1979 figures are more realistic for a healthy United States economy when compared to more current consumption figures which reflect the recent worldwide recession. The industries listed in Table III-7 account for 75 percent of total U.S. chromium consumption. Those listed in Table III-8 account for 78 percent of all the chromium U.S. firms used to produce defense goods.<sup>14</sup>

#### **UNITED STATES' CONSUMPTION OF CHROMIUM**

Industries use chromium in several different forms: high carbon ferrochromium, low carbon ferrochromium, chromium metal, chemical grade chromite, refractory grade chromite and others. The first three have numerous defense-related uses and the bulk of chromium consumed in the United States is in the form of high carbon ferrochromium.

The direct industrial uses of chromium are broadly classified as metallurgical, chemical and refractory. On the average, of the total chromium consumed, the metallurgical industry consumes 50-75 percent, the

TABLE III-6  
CRITICAL CHROMIUM NEEDS  
IN BASIC INDUSTRY & MILITARY TECHNOLOGY

ORDINANCE (Tanks, fighters, bombers, missiles)

POWER GENERATION (Turbines, controls, transmissions)

ALL ELECTRONICS (Appliances, computers, phones, TV, navigation, controls, telecommunications)

NUCLEAR APPLICATIONS

JET ENGINES, GAS TURBINES (Hot parts)

AEROSPACE (Airframes, hulls, rocket engines)

PROJECTILES, GUN BARRELS, MACHINE PARTS, CRANKSHAFTS, AXLES, GEARS, MACHINE TOOLS

MINING, DRILLING (Valve stems & systems, drill bits)

HIGH TECH. MEDICAL (Cryogenics, heart-lung, scanners)

PETROLEUM PROCESSING, DRILLING

CHEMICAL PROCESSING

FODD PROCESSING, ENRICHMENT

SYNFUEL PRODUCTION

Source: 13

TABLE III-7  
LEADING CHROMIUM-USING INDUSTRIES FOR DEFENSE  
AND CIVILIAN PRODUCTION IN 1979

<u>Industry*</u>	<u>Thousands of Short Tons Used</u>	<u>Tons Used Per \$1 Million of Industry Shipments</u>
Nonferrous Rolling & Drawing NEC**	37.69	11.25
Metal Stampings	28.81	4.59
Blast Furnaces & Steel Mill Products	27.49	0.41
Motor Vehicle Parts & Accessories	24.10	0.61
Construction	23.00	0.20
Fabricated Platework	21.50	2.36
Crude Petroleum & Natural Gas	19.08	1.18
Iron & Steel forgings	16.94	4.85
Pipes, Valves & Pipe Fittings	15.83	1.61
Hardware NEC**	14.52	2.33
Aircraft Engines & Engines Parts	13.91	1.43
Refrigeration & Heating Equipment	12.77	1.04
Fasteners & Screw Machine Products	11.19	1.63
Sheet Metal Work	9.79	1.58
Aircraft Parts & Equipment NEC**	8.83	1.22
Misc. Fabricated Wire Products	8.57	4.60
Special Dies, Tools & Accessories	7.90	1.48
Measuring & Dispensing Pumps	7.31	16.29
Metal Sanitary Ware	7.18	12.93
Food Products Machinery	7.06	3.11
Fabricated Metal Products NEC**	7.05	1.49
Steam Engines & Turbines	6.84	2.21
Miscellaneous Machinery	6.70	0.56
Electronic Components NEC**	6.46	0.77
Ball & Roller Bearings	5.78	1.69
Electric Housewares & Fans	5.56	1.94
Miscellaneous Metal Work	5.15	2.48
Service Industry Machines NEC**	5.06	2.38
Special Industrial Machinery NEC**	5.01	1.11
Complete Guided Missile Systems	4.40	0.62
Farm Machinery	4.38	0.34
Mining	4.21	0.06
Other Industries	125.81	NA
TOTAL:	515.87	--

Average Ratio For Leading Chromium-Using Industries: 2.82  
 Average Ratio For All Manufacturing Industries: 0.27

\* The 32 industries listed below are ranked by their consumption of chromium in 1979. They are the leading users of chromium because they accounted for 75 percent or more of U.S. chromium consumption that year.

\*\* not elsewhere classified

SOURCE: 14

TABLE III-8  
LEADING CHROMIUM-USING INDUSTRIES  
FOR DEFENSE OUTPUT IN 1979

<u>Industry a/</u>	<u>Thousands of Short Tons Used For Defense Goods</u>	<u>Tons Used For Defense Per \$1 Million of Defense Shipments</u>
Aircraft Engines & Engine Parts	5.46	1.40
Aircraft Parts & Equipment NEC*	3.67	1.82
Complete Guided Missiles	3.29	0.65
Nonferrous Rolling & Drawing NEC*	3.10	NA**
Radio & TV Communication Equipment	1.85	0.23
Shipbuilding & Repairing	1.63	0.65
Ammunition, except small arms NEC*	1.62	1.97
Electronic Components	1.21	4.13
Blast Furnaces & Steel Mill Products	1.14	NA
Iron & Steel Forgings	1.08	NA
Metal Stampings	0.81	NA
Fabricated Platework	0.71	4.04
Fasteners & Screw Machine Products	0.71	NA
Tanks & Tank Components	0.70	0.90
Steam Engines & Turbines	0.49	2.99
Other Industries	7.63	NA
<b>TOTAL:</b>	<b>35.12</b>	<b>--</b>

\* not elsewhere classified

\*\* not available

a/ The 15 industries listed below are ranked by their consumption of chromium for defense production in 1979. They are the "leading" users of chromium because they accounted for 75 percent or more of all the chromium that U.S. firms used in producing defense goods that year.

SOURCE: 14

chemical industry 10-35 percent, and the refractory industry 10-15 percent.

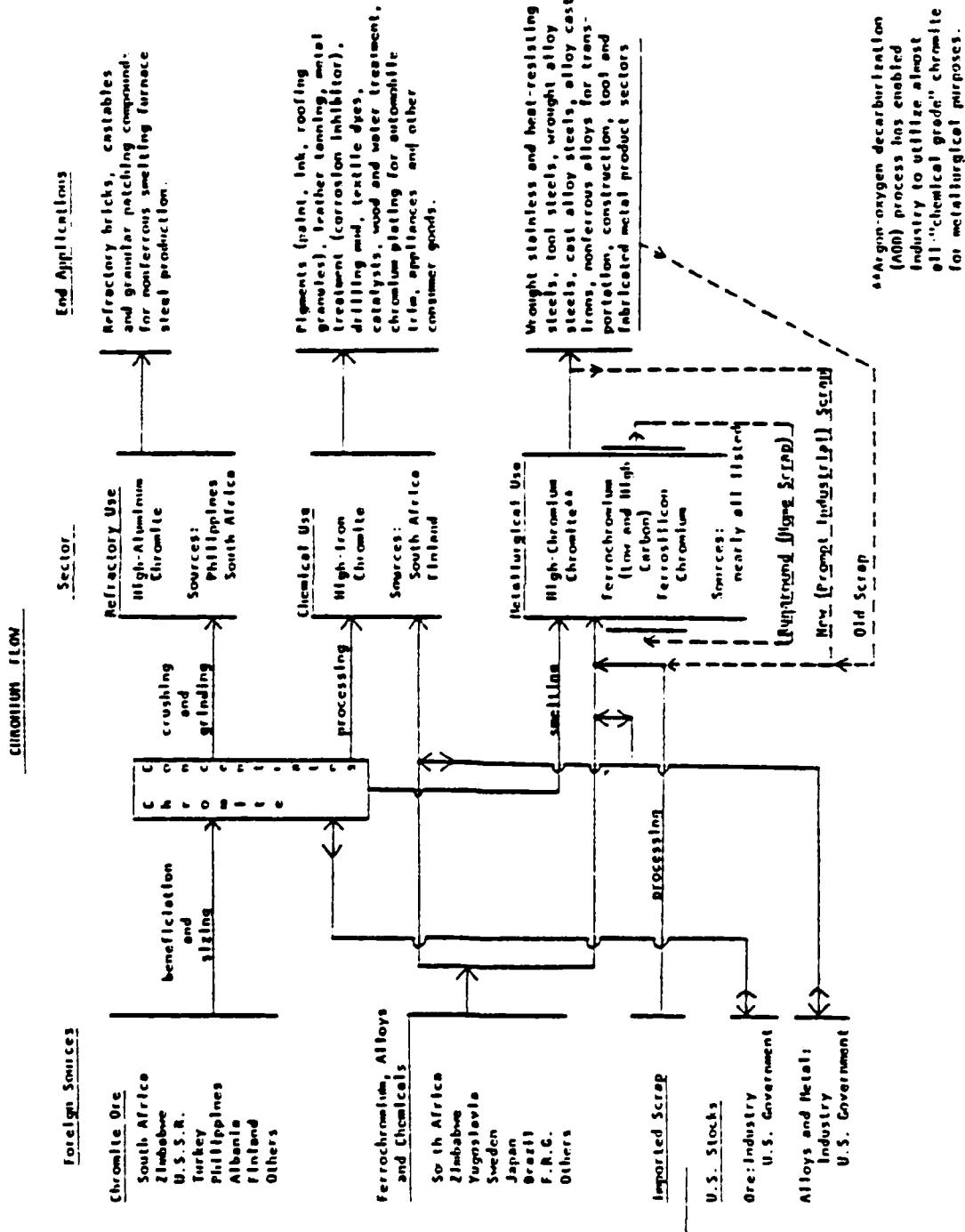
Figure III-2 provides a chromium flow chart which neatly summarizes foreign sources, processing, uses by industrial sector, and applications for chromium.

#### **Metallurgical Industry Consumption**

The largest use of chromium by the steel industry is in the production of stainless steel and heat-resisting steels. These two categories together account for about 75 percent of the total chromium consumption in steelmaking.<sup>15</sup> Chromium is the most versatile and essential alloying material for the speciality steel industry. The inclusion of chromium in the production of stainless, heat-resisting, full-alloy, high-strength low-alloy (HSLA), and tool steels enhances such properties as hardenability, creep and impact strengths, and resistance to heat, corrosion, oxidation, wear and galling. Stainless steel is by far the largest of user of chromium (Table III-9).

The second largest steel industry use of chromium (19 percent)<sup>15</sup> is in the production of full alloy steels. Full alloy steels generally contain between 0 and 1.7 percent chromium, often in combination with slightly larger amounts of nickel and smaller amounts of molybdenum.<sup>15</sup> These alloying elements impart a high tensile strength and heat and creep resistance to full

FIGURE III- 2  
CHROMIUM FLOW CHART



SOURCE: 15

TABLE III-9

REPORTED U.S. METALLURGICAL  
CONSUMPTION OF CHROMIUM\* BY END USE  
(000 short tons, chromium content)

<u>END USE</u>	<u>1977</u>	<u>1978</u>	<u>1979</u>	<u>1980</u>	<u>1981</u>
Carbon	3.7	4.6	4.6	3.5	5.0
Stainless	186.9	201.3	222.8	173.6	172.8
Full Alloy	42.5	51.1	55.0	41.6	47.9
HSLA	8.7	8.0	7.3	6.5	6.3
Tool	3.3	4.2	3.4	2.8	2.7
TOTAL STEEL	245.2	269.2	293.0	228.0	234.7
Cast Irons	8.6	9.9	9.8	6.4	6.4
Superalloys	8.1	11.0	12.5	11.7	7.0
Welding Materials	1.4	1.8	1.9	1.3	1.2
Other Alloys	3.1	3.8	4.1	3.5	2.4
Miscellaneous	2.2	2.2	2.2	1.6	2.0
TOTAL	268.6	298.0	323.5	252.5	279.2

\* Chromium ferroalloys and metal.

SOURCE: 15

alloy steels.

Relatively minor amounts of chromium are consumed in the production of HSLA, tool and carbon steels.

After steel, the next largest metallurgical user of chromium has been the superalloys sector, accounting for an average 3.6 percent of reported metallurgical consumption. The term superalloys is not well defined, referring generally to a variety of exotic alloys developed to accommodate high temperature, high stress and extreme oxidation/corrosion resistance requirements. There were times when superalloys were strictly thought to be jet engine materials, but the market for superalloys is expanding rapidly. Superalloys are beginning to find their way into many of the newer, emerging industries such as in sour gas wells, coal conversion plants, utility scrubbers, fast breeder reactors and, potentially, fusion reactors.<sup>16</sup>

Alloy cast irons are the next largest group in terms of demand, averaging 2.9 percent of metallurgical consumption.<sup>15</sup>

Non-ferrous alloys, not considered superalloys, contain 0.1 to 0.3 percent chromium but are aluminum-based alloys used in space vehicles, aircraft, marine craft and surface vehicles in a variety of local-bearing applications. The Bureau of Mines categorizes them as "other alloys," and they average 1.2 percent of

metallurgical consumption.<sup>15</sup>

The remaining 1.3 percent of metallurgical consumption is made up by welding materials and miscellaneous uses.

A final metallurgical application of chromium, chromium plating, is a low cost alternative to the use of chromium-bearing alloys when all that is needed is a decorative or tarnish-resisting surface. Consumption is about 3-4 percent of total chromium used and includes some chemical and refractory uses, too.<sup>15</sup>

#### **Chemical Industry Consumption**

The chemical industry consumption of chromium made up about 11 percent of apparent total consumption for the five years prior to the recent recession. The primary applications are in pigments and paints (the largest chemical application for chromium), leather tanning, and other uses that take advantage of special properties of chromium chemicals include drilling muds, textile dyes, catalysts for hydro generation and polymerization reactions, magnetic tapes and wood and water treatment.<sup>3</sup>

#### **Refractory Sector Consumption**

The refractory sector, historically the main user of high-aluminum chromite ore has accounted for an average 12 percent of total apparent chromium consumption over the last seven years. The major use for chromite-bearing refractories materials was in open hearth steel furnaces.

The decline in demand for these products which accompanied the phasing out of open hearth furnaces has been offset only partially by their use in electric arc furnaces. Chromite-bearing refractories are also utilized in non-ferrous alloy refining, glass-making and cement manufacture. Chromite sand is used as a molding material in the foundry production of ferrous castings and in maintenance gunning mixtures for steelmaking furnaces. Refractories are supplied as granular materials or shaped brick. Chromium is used in refractory products to decrease both thermal shock and slag corrosion and to enhance volume stability and structural strength.<sup>15</sup>

#### UNITED STATES IMPORTS OF CHROMIUM

U.S. net import reliance for chromite and ferrochrome materials combined historically exceeds 90 percent during economically healthy periods:

TABLE III-10  
U.S. NET IMPORT RELIANCE AS A PERCENT OF CONSUMPTION

<u>1973</u>	<u>1974</u>	<u>1975</u>	<u>1976</u>	<u>1977</u>	<u>1978</u>	<u>1979</u>	<u>1980</u>	<u>1981</u>	<u>1982</u>	<u>1983</u>
91	90	91	89	91	92	90	91	90	85	77

SOURCE: 5

Table III-11 shows U.S. chromite and ferrochrome imports in 1981 and 1976. Interestingly, chromite imports decreased significantly from 1976 to 1981 while ferrochromium imports increased significantly. Imports from the Republic of South Africa led this trend. Also, note how the percent of total U.S. chromium imports from

TABLE III-11  
U.S. CHROMIUM IMPORTS IN 1981 (& 1976)  
(Thousand short tons)

Country	Chromite		Ferrochromium		Total Chromium content of Chromite and alloys <sup>1</sup>	Percent of Chromium Imports
	Gross Weight	Chromium Content	Gross Weight	Chromium Content		
South Africa	482(439)	144(132)	263(89)	141(48)	285(120)	56.1(35.9)
Zimbabwe	--(34)	--(10)	71(61)	45(36)	45(46)	8.8(9.2)
Philippines	145(167)	36(37)	2(--)	1(--)	37(37)	7.4(7.4)
U.S.S.R.	111(189)	33(61)	--(--)	--(--)	33(61)	6.5(12.2)
Yugoslavia	--(NA)	--(NA)	47(NA)	31(NA)	31(NA)	6.0(NA)
Turkey	49(212)	14(61)	8(1)	5(1)	19(61)	3.8(12.2)
Finland	78(169)	16(34)	--(--)	--(--)	16(34)	3.2(6.8)
Brazil	--(--)	--(--)	21(28)	11(16)	11(16)	2.2(3.2)
Sweden	--(NA)	--(NA)	11(NA)	8(NA)	8(NA)	1.5(NA)
	2	3	3	4	5	6
Other	--(44)	--(13)	15(77)	10(52)	10(65)	2.1(13)
Total	898(1276)	252(349)	443(256)	255(152)	507(501)	100.0(100)

<sup>1</sup>Data may not add to totals shown because of independent rounding.

(NA) Not available for these countries separately in 1976.

2                   3           4           5  
Albania-18, India-18; Japan-39; Japan-25; Albania-5,  
India-5, Japan-25; 6Albania-1, India-1, Japan-5.

Source: 4

South Africa increased from 35.9 percent to 56.1 percent in just five years.<sup>4</sup>

#### **WORLD MARKET OUTLOOK FOR CHROMIUM**

General agreement seems to occur among the BOM and independent authors on the future demand, supply and prices in the chromium market this and next decade. They all suggest modest, yet positive, annual growth. The future of the U.S. steel industry will be the major factor for domestic growth.

#### **Demand Projections<sup>4</sup>**

Primary chromium requirements of the United States in 2000 are expected to range between about 500,000 and 900,000 tons. An analysis of factors contributing to the high and low forecasts indicates that the most probable demand for primary chromium in the year 2000 will be about 700,000 tons, representing an average annual growth rate of about 2% for the 1983-2000 period. The probable primary demand in 1990 is forecast at about 600,000 tons. Statistical regression analysis of historical end-use data correlated with economic indicators such as gross national product (GNP) and various Federal Reserve Board (FRB) indexes was used to provide a statistical projection base shown in table III-12. Contingency analyses of each end use were then made of possible technologic, economic, and social factors that could affect the use of chromium directly or indirectly, tempered by judgment. The best-

TABLE III-12  
PROJECTIONS AND FORECASTS FOR U.S. CHROMIUM, BY USE  
(Thousand tons of chromium)

<u>End Use</u>	<u>1981</u>	<u>2000</u> <u>Contingency forecasts for U.S.</u>			
		<u>Statistical Projections</u>	<u>Forecast</u>	<u>Range</u>	<u>Probable</u>
Transportation	103	219	140	220	170
Construction	95	128*	110	150	130
Machinery	90	170*	90	130	120
Household appliances	48	90	60	160	90
Refractories	29	10*	20	60	30
Plating of metal	18	31	20	30	30
Chemicals	62	126*	60	150	100
Other	65	80*	70	130	110
 Total	 510	 ---	 570	 1030	 780

<sup>1</sup>Statiscal projections, provided by the Branch of Economic Analysis, are derived from regression analysis based on historical time series data and forecast of economic indicators such as GNP, FRB Index. Projection equations with a coefficient of determination (R squared) less than 0.70 are indicated by an asterisk(\*).

Source: 4

fit explanatory and use variables for each statistical projection are as follows: construction and other uses with FRB Iron and Steel index; refractories with population; plating of metals, machinery, and transportation with gross private domestic investment; household appliances with FRB Fabricated Metals Products index; chemicals with FRB Chemicals and Products index.<sup>4</sup>

Demand for primary chromium in the rest of the world in the year 2000 is expected to range from 2 to 3 million tons, with the most probable demand forecast at 3.0 million tons corresponding to an annual growth rate of about 3%.<sup>4</sup> The rest-of-world primary demand growth rate is expected to exceed that of the United States, primarily because of increasing industrialization by countries with resources and low-cost energy and by those less developed countries that have capital for new steel plants.

Cumulative probable primary chromium requirements in the United States to the year 2000 total about 11 million tons. The cumulative probable demand for chromium in the rest of the world is about 44 million tons, bringing the total world cumulative probable demand to about 55 million tons.<sup>4</sup> A major factor affecting actual consumption is the general level of economic activity.

The forecasts presented in table III-13 are estimated long-term economic performance based on

TABLE III-13  
 SUMMARY OF FORECASTS OF U.S. AND REST-OF-WORLD  
 CHROMIUM DEMAND, 1990 and 2000  
 (Thousand short tons of chromium)

	2000 Forecast Range			Probable 1990	Probable 2000	Probable average annual growth rate 1981-2000 (percent)
	1981	Low	High			
<b>United States:</b>						
Primary	455	500	900	580	690	2.2
Secondary	55	70	120	80	90	2.8
Total Cumulative (primary)	510	570	1030	660	780	2.2
<b>Rest of world:</b>						
Primary	1669	2300	3600	2200	3000	3.2
Secondary	181	240	380	230	320	3.0
Total rest of world Cumulative (primary)	1850	2500	3900	2400	3300	---
<b>World:</b>						
Primary	2124	2800	4500	2800	3690	3.0
Secondary	236	310	500	310	410	3.0
Total Cumulative (primary)	2360	3100	5000	3100	4100	3.0
<b>1</b>						
Growth rate based on 20-year trend from 1981 demand to probable 2000 demand.						
<b>2</b>						
Data may not add to totals shown because of independent rounding.						

Source: 4

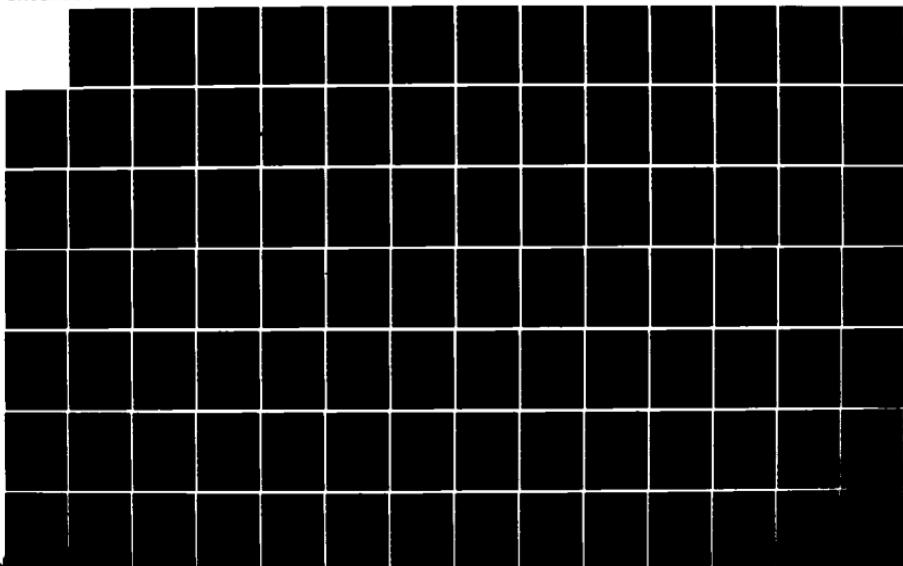
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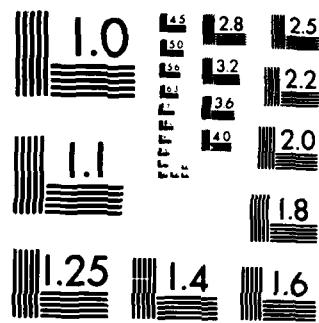
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MICROCOPY RESOLUTION TEST CHART  
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historical performance. It is not implied that economic performance for a short time will approximate the long-term estimate.

#### **Supply Projections**

None of the U.S. chromite resources are considered reserves because most of the ore cannot economically compete with foreign ore at present. The differential in cost of domestic chromium, including transportation costs from the Western States, and cost of delivered chromium from foreign sources removes the domestic material from consideration as a supply source except for possible emergency needs. However, high prices, problems in obtaining imported chromium, or advances in chromium technology, may cause increased domestic consumption of secondary sources of chromium recovered from processing scrap, obsolete equipment and industrial waste.

World reserves (Table III-2), particularly those in Africa, are more than adequate to fulfill U.S. and rest-of-world cumulative demand to the year 2000 (Table III-14).

TABLE III-14  
ADEQUACY OF U.S. AND WORLD CHROMIUM RESERVES  
(Thousand short tons of chromium)

	<u>U.S.</u>	<u>Rest of World</u>	<u>World Total</u>
Reserves	--	370,000	370,000
Cumulative primary demand 1981-2000	10,800	43,800	54,600

Source: 4

Use of lower grade chromite and fine materials by more efficient processing methods and recovery of chromium from laterites may be factors in lowering unit costs and improving supply in the long-term. This is especially true for producers with dwindling reserves. Known world laterite deposits, primarily in the tropics and subtropics, contain an estimated 50 million tons of chromium, and development of an economical technology would extend world resources and enlarge the geographical supply base.<sup>4</sup>

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## CHAPTER IV

### THE DEMISE OF THE DOMESTIC FERROCHROME INDUSTRY

#### INTRODUCTION

Historically, the more highly developed countries (i.e. U.S.A., Japan, EEC) have been the largest producer of ferrochromium alloys. However, trends of the past decade, and today, favor countries with low-cost energy, less stringent environmental constraints, and natural resources to install furnace capacity for the production of chromium alloys.

#### TECHNOLOGICAL FACTORS

The carbon content of ferrochromium is particularly important to the production of stainless steel. Excessive carbon content will reduce the corrosion resistance of the product. The goal of most research and development in the ferrochromium industry has been to develop an efficient method of carbon reduction. In the interwar years when ferrochromium had a carbon content of 4 percent, iron and chromium oxides were used to carry off the carbon. This method meant that all too little chromium entered the metal while the large amounts of chrome in the slag had to be recovered by the use of expensive ferro-silicon.<sup>1</sup>

By 1940, a low-carbon ferrochromium was available from metallurgical grade ores found in Turkey, Russia and Zimbabwe. However, low-carbon ferrochrome (0.5 percent

carbon) was very expensive and a less costly approach to stainless steel was soon developed. An inexpensive new alloy, ferrochromium-silicon, was perfected which was utilized in conjunction with the cheaper high-carbon ferrochromium to produce stainless steel at a cost savings of \$5 per ton.<sup>1</sup> Nevertheless, low-carbon ferrochromium remained the mainstay of the metallurgical industry until the 1970's.

#### **Past Technological Improvements**

In 1955, a discovery was made by Union Carbide which revalidated the idea that resources can actually increase in the face of growing depletion. New technology in the form of the Argon-Oxygen Decarburization Process (AOD Process) made it possible to utilize low-chromium (chemical grade) ores in the metallurgical industry.<sup>1</sup> Thus, the vast deposits of chromite in South Africa, heretofore suitable only for the limited chemical industry market, became metallurgical industry reserves of the first order.

In the AOD process the carbon in the melt is reduced by means other than the oxidation of chromium. When oxygen is blown into the furnace, carbon monoxide is formed above and within the melt. Union Carbide found that if the partial pressure of the carbon monoxide was reduced to a certain level, carbon would be eliminated in lieu of chromium. To achieve the partial pressure

reduction, the oxygen added is modified to include a specified quantity of argon gas. Combining this inert gas with oxygen and raising the melt temperature to the 1720 C range has enabled the AOD process to succeed, where other methods have not, in eliminating the excess carbon found in high-carbon ferrochromium. Thus, technology has once-again modified the spatial configuration of chromium resource dependencies by enabling the producers of stainless steel to utilize the more abundant supply of low chromium chromite.<sup>1</sup>

#### **Future Technological Expectations**

Addressed in the last chapter, the next great technological breakthrough for the world ferrochrome industry may be the implementation of the plasma arc furnace to replace the submerged arc furnace.

The process offers a number of distinct advantages. The furnaces are capable of employing chromite fines without any agglomeration, thereby lowering costs. One of the great advantages of plasma smelting is that at very high temperatures, no materials are lost as slag. Experts expect a slightly better ferrochrome as the plasma smelting process optimizes temperature, feed rates, composition, arc length, voltage and power, all through precise control of the arc current.<sup>2</sup> The process can also employ cheaper, fine, high-ash coal rather than metallurgical coal as a reducing agent.<sup>3</sup> Other advantages

include, the replacement of costly graphite electrodes required in SAF's by water-cooled plasma electrodes; and the small holding capacity and low time constant of the plasma furnace.<sup>4</sup>

European and South African ferrochrome producers are the leaders in developing this technology. The South African experts believe that optimum solutions for the industry application of plasma arc furnaces will be developed within the next two years. Several U.S. industry officials believe that time frame is overly optimistic. They believe that its industrial application remains about 7-8 years away.<sup>4</sup>

#### **ECONOMIC FACTORS**

The advent of the AOD process brought about marked changes in the world and domestic chromite and ferrochrome markets.

##### **International Price Changes**

Over the last two decades there has been a pronounced shift away from the use of low-carbon ferrochromium for reasons of economics. Low-carbon ferrochromium, typically, has a carbon content of between .01 and .05 percent and a chrome content of between 65 and 75 percent.<sup>5</sup> The chromite deposits from which this ferrochromium is processed are the high-chromium podiform ore deposits such as those in Turkey, the price for which is \$110 per metric ton.<sup>6</sup> High-carbon ferrochromium or

"charge-chrome", as it is called in South Africa, has a carbon content of between 4 and 8 percent and a chrome content as low as 55 percent.<sup>5</sup> The cost of South African chromite in 1983 was \$52 per metric ton.<sup>6</sup> In addition to this price differential, the AOD process greatly reduces the quantity of chromium lost through oxidation. Therefore, the stainless steel producer utilizing the AOD process and high-carbon ferrochromium will require less chromium to produce a ton of product than would be necessary using the more expensive low-carbon ferrochromium.

#### **International Market Changes**

It is not surprising, then, that as the AOD process reached production maturity in the early 1970s, it brought with it a major change in the world ferrochromium market. In 1963, high-carbon ferrochromium comprised 54 percent of total U.S. ferrochromium consumption. By 1973 it had risen to 74 percent and by 1980 the figure was 87 percent.<sup>7</sup> Similar trends occurred in Western Europe and Japan.

At the same time that high carbon ferrochromium was increasing trade in the world market, another major shift in the form of chromium imports occurred. The patterns of U.S. and world chromium trade reflect a decrease in chromite ore imports corresponding to a rise in ferrochromium imports. For example, in the U.S. in

1971, chromite held the preeminent position among imports of chromium with approximately 80 percent of the market while ferrochromium lagged well behind with 20 percent. By 1981, the chromium import market was split almost evenly between ferrochromium and chromite (Table III-11).<sup>8</sup>

The technological innovations which enabled the occurrence of this phenomenon set the stage for the transfer of the metals processing industry from the core areas of major industrial heartlands to the periphery of lesser developed nations. The coincidence of low-chromium deposits of chromite (now suitable for the production of ferrochromium) with low cost sources of energy, encouraged the chromite producing nations to re-examine traditional patterns of trade. The realization that such a coincidence offered a comparative advantage to those who were able to move into down stream minerals processing resulted in an aggressive entry in the ferrochromium industry by the heretofore "exploited" nations. Thus, an important trend toward mine-sight ferrochromium production was begun.

The industrialized nations smelted virtually all of their ferrochromium from chromium ore imports before the advent of the AOD process. However, as the AOD process spread through the industry, comparative advantage dictated the location of new processing sites. In 1970, ore producing countries exported 440,000 metric tons of

ferrochrome. This figure had grown to 1,370,000 metric tons by 1979.<sup>1</sup>

This ground swell of mine-site ferrochromium production has severely reduced ferrochromium production in the West. Plants which are high-cost or obsolete have been eliminated. In Japan, 250,000 to 300,000 tons of ferrochromium production has been eliminated. Europe has rationalized 150,000 tons of capacity, and it is estimated that before 1985 "there will be no significant high-carbon ferrochrome production in the European Economic Community."<sup>1</sup> Indeed, the U.S., which in 1960 accounted for 39 percent of the West's ferrochromium output, today has one furnace operating.

Projections call for this trend to continue. The 1980 high-carbon ferrochromium production capacity for all nations, except Russia and East Europe, totalled 2.5 billion pounds of contained chromium. South Africa, taking advantage of its comparative advantage, accounted for 48 percent of this figure. Industrialized nations of the West produced an additional 41 percent while 11 percent originated in other chromite producing countries.<sup>1</sup> According to the Chairman of Union Carbide Southern Africa Incorporated, Mr. J. W. Rawlings, the capacity will increase to 3.3 billion pounds by 1990, with the greatest share of market growth going to South Africa. The West's share will erode to 19 percent while other ore

producing nations will grow modestly to account for 13 percent. Southern Africa's dominance will continue, giving the mineral rich country's 68 percent of the total.<sup>1</sup>

The trend toward greater production of ferrochromium in the chromite producing countries will probably continue. South Africa, Turkey and India are expected to register the largest growth in ferrochromium production over the next five years. Other producers, such as Zimbabwe, Brazil, Greece and Finland, are also expected to increase ferrochromium production, albeit to a lesser extent. In addition, several ore-producing countries, most significantly Albania and the Philippines, have just begun to produce ferrochromium in the last two or three years.<sup>7</sup>

#### **Domestic Industry Shutdowns**

Earlier, this author discussed the existence of only one operating furnace for the domestic production of ferrochrome in mid-1984. The decline in the number of firms producing ferrochrome over the past 13 years has been enormous. In 1971, the U.S. had 11 plants which produced chromium alloys. In 1982, seven firms listed in Table IV-1 were producers of chromium ferroalloys and metal. Concurrent with the growth in mine-mouth and other overseas processing of chromium ferroalloys, imports have now assumed the major role in the domestic market. The

TABLE IV-1  
U.S. PRODUCERS OF CHROMIUM FERROALLOYS & METAL (1982)

<u>Producer</u>	<u>Plant Location</u>	<u>Products</u>
Chromasco, Ltd.	Woodstock, TN	HCFeCr
Elkem Metals Co.	Alloy, WV	HCFeCr, LCFeCr
	Marietta, OH	Cr metal
Interlake, Inc.	Beverly, OH	HCFeCr, LCFeCr
Macalloy Corp.	Charleston, SC	HCFeCr
Satralloy, Inc.	Steubenville, OH	HCFeCr, LCFeCr
SKW Alloys, Inc.	Niagara Falls, NY	FeCrSi
Shieldalloy Corp.	Newfield, NJ	Cr metal

Source: 7

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TABLE IV-2  
1983 U.S. IMPORTS OF CHROMIUM FERROALLOYS AND METAL  
(000 Short tons)

Republic of South Africa	152
Zimbabwe	54
Yugoslavia	33
Turkey	15
Brazil	8
Norway	1
Others	22
Total	285

Source: 9

low level of industrial activity as a result of the prolonged 1981-82 recession has pushed capacity utilization to their lowest levels. Finally, domestic energy and environmental costs, together with the strength of the dollar, have contributed to difficulties confronting domestic ferrochromium firms. The one firm operating in mid-1984, Macalloy Corp., is hoping to keep renewing the annual stockpile upgrade contract, utilizing the money for company reorganization plans.<sup>10</sup> Macalloy is capable of producing on the average of 100,000 to 120,000 short tons of high carbon ferrochromium annually. The plant has two large submerged arc furnaces (SAF) of 35MW and 45MW ratings.<sup>11</sup> Looking at Table III-5, these are the two largest SAF's in the USA. One furnace will be reactivated to process 121,000 short tons of stockpiled chromite ore into 50,000 short tons of HCFeCr. Macalloy's bid represents 90 percent of the first year program objectives.<sup>10</sup> The true measure of the dire straits in which the U.S. ferrochrome industry finds itself is reflected in the fact that this large, efficient producer has been operating under Chapter XI bankruptcy proceedings since December of 1981. Also, 1984 domestic production is hitting all time lows while the GNP is growing at its highest rate in three decades.

#### **Current Domestic Industry Operating Levels**

U.S. ferrochrome imports as a percent of the total

domestic market rose from 59 percent in 1980 to 83 percent in 1983. Table IV-2 shows the imports by country of origin.

Over the past 15 years, as Table IV-3 shows, domestic ferrochrome production decreased and imports increased. Domestic producers have not been able to re-establish the market share they lost during the 1981 recession. Table IV-4 shows the import trends of ferrochrome in its various forms. Note that the most widely utilized, and most important, HCFeCr is also the one with the highest import dependence.

#### **POLITICAL FACTORS**

The importance of chromium was stressed in a recent MacNeil-Lehrer report as follows: "In World War II it wasn't the shortage of oil that halted the Nazi war machine. What they ran out of was chromium."<sup>12</sup> A recent study by the West German Cabinet indicated that a 30 percent decrease in that nation's chromium imports would cause an astronomical 25 percent decline in the West German GNP.<sup>13</sup>

#### **International Political Changes**

Historically, world political problems have brought supply disruptions for chromium. Because of the Korean conflict, the Soviet Union in 1950 embargoed exports of chromite to the United States. They re-entered the market in 1960, although it was 1963 before

TABLE IV-3  
DOMESTIC PRODUCTION - IMPORTS - MARKET SHARE  
CHROMIUM FERROALLOYS AND METAL  
(000 Short tons)

	<u>DOMESTIC PRODUCTION</u>	<u>IMPORTS</u>	<u>DOMESTIC PRODUCERS MARKET SHARE %</u>
1970	343	43	89
1971	345	88	80
1972	339	152	69
1973	457	171	73
1974	442	172	72
1975	210	325	21
1976	250	261	49
1977	264	243	52
1978	226	331	41
1979	273	246	65
1980	206	306	40
1981	174	446	33
1982	114	151	43
1983	57	285	17
1984 1st Qt	16	159	9

Source: 9

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TABLE IV-4  
IMPORTS AS PERCENT OF APPARENT MARKET

	<u>1970</u>	<u>1975</u>	<u>1980</u>	<u>1981</u>	<u>1982</u>	<u>1983</u>	<u>3 mos. 1984</u>
H.C.Ferrochrome	6	65	62	73	58	88	94
L.C.Ferrochrome	22	65	45	57	76	68	76
Ferrochrome Silicon	0	9	25	43	46	13	54
Chromium Metal	45	37	53	55	46	53	61
All Chromium	11	61	60	72	51	83	91

Source: 9

significant quantities were received. Southern Rhodesia's Unilateral Declaration of Independence in 1965 brought United Nations economic sanctions in 1966. Except for chromite purchased prior to sanctions, imports of Rhodesian chromium were embargoed by the United States from early 1966 to 1972. The situation was considered so unacceptable that the U.S. government passed an amendment to a military appropriation bill (Byrd amendment) in late 1971, allowing the importation of critical and strategic materials, including chromium, from Rhodesia. In mid-March 1977, a law became effective nullifying the Byrd amendment, and also requiring any country exporting steel mill products to the United States to certify that such products contained no chromium of Rhodesian origin. Closure of the Rhodesian-Mozambique border by the Mozambique Government in 1976 reduced Rhodesian chromium shipments from the port of Maputo.<sup>14</sup>

Unrest in Zimbabwe-Rhodesia escalated in recent years. Actions by the United States and the United Kingdom demonstrated international concern for an end to the civil and political unrest that restricted the normal growth of a stable economy in which the mineral industry plays a vital role. International recognition of a new government and achievement of independence on April 18, 1980, led to the lifting of sanctions against products from Rhodesia, now called Zimbabwe, by the United Nations,

including the United States.<sup>14</sup>

#### **Domestic Political Changes**

Concerning domestic political changes, this author will discuss: the current status of the domestic ferrochrome industry as a national security problem; government agency investigations of this security problem; Department of Commerce findings and recommendations to solve this national security dilemma for ferrochrome; presidential decisions on these recommendations; and the position and proposals of interest groups for the domestic ferrochrome industry.

#### **National Security Problem Created**

From the standpoint of concern for the national security, there is a tremendous difference between dependence on processed materials and dependence on raw materials. Grave as is our reliance on foreign crude oil, just imagine how much worse it would have been in 1973 if we had had little or no capacity to refine crude oil. When a nation has a viable smelting or refining capacity, it can satisfy its essential needs so long as it can obtain or has the raw materials. It is of grave concern to many that the United States seems to be embarked on a hazardous path leading to the loss of much of its primary smelting capacity, not only in ferroalloys but also in the steel, aluminum and some non-ferrous metals industries, becoming more and more dependent on processed products,

thus increasing vulnerability to supply interruptions.

Without the furnace capacity to produce ferroalloys, the nation's supply options would depend upon those countries possessing processing capacity, and their willingness or ability to supply our needs. Without a domestic ferroalloy processing capacity, it would be useless to search for ore deposits, either in our country or elsewhere, and the ores in the national stockpile would be a pile of useless rocks. The present, almost complete, dependency on the foreign processing of chromium ore to ferroalloys is a needless risk to the national security and additionally exposes our economy to the probability of exorbitant pricing of imports during future periods of high demand.

#### **Government Agency Investigations**

Government investigations, usually requested by the Ferroalloys Association, deal with two import themes, injury to the domestic production industry for ferroalloys, and threats to national security.

#### **Domestic Industry Injury Cases**

A total of four investigations were conducted to determine if ferrochromium products were being imported into the United States in such increased quantities as to cause, or threaten to cause, serious injury to the domestic industry. These were carried out first under Section 301 of the Trade Expansion Act of 1962 and then

under Section 201 of the subsequent Trade Act of 1974. In a May 1973 case, which covered chromium and other ferroalloys and metals, the petitioner withdrew its application after a month and the investigation was discontinued without a determination of its merits and without prejudice. In July 1977, the International Trade Commission (ITC) determined after a seven-month investigation that imports of LCFECr were not threatening the domestic industry with serious injury. In December 1977, a positive finding was made by the ITC with regard to HCFECr and increased tariff rates were recommended. In January 1978, the President determined that the relief recommended by the Commission was not in the nation's economic interest.<sup>7</sup>

Responding to requests from industry and from Congress, a reinvestigation of the HCFECr case was instituted in early 1978, which again led to a positive finding and recommendation of increased tariff duties or quotas. In November 1978, the President proclaimed a three-year duty increase of 4 cents per pound of chromium content for all HCFECr imports valued at 38 cents/lb. or less (f.o.b., port of exit). Most recently, an investigation was conducted to determine whether an extension of this escape clause relief on HCFECr was warranted. In September 1981, the ITC advised the President that termination of the import relief would have

a significant adverse economic effect on the domestic industry. The Commission recommendations included extension of the relief modified to compensate for inflation or the negotiation of orderly marketing arrangements. A one-year extension of the existing relief was granted by the President in November 1981 concurrent with a request to the Secretary of Commerce to expedite the Section 232 investigation.<sup>8</sup>

As a result of this investigation, the President moved, on November 29, 1982, to begin a program to process stockpiled chrome ore into approximately 519,000 short tons of high carbon ferrochromium during the next ten years. This stockpile upgrading program was designed to meet two objectives: 1) to decrease the amount of stockpile ore requiring conversion to ferroalloy form in time of national emergency, and 2) to help maintain domestic ferrochrome furnace and processing capacity.<sup>10</sup>

#### **National Security Injury Cases**

Since the passage of the Trade Expansion Act of 1962 and the subsequent Trade Act of 1974, there have been numerous requests by the domestic industry for investigations regarding unfair or injurious import competition. Four separate investigations of the impact of chromium ferroalloys on the national security were conducted under Section 232 of the 1962 legislation. Twice, in July 1964 and again in August 1970, it was

determined upon completion of such investigations that ferrochrome was not being imported into the U.S. in such quantities or under such circumstances as to threaten to impair the national security. A ruling in the fourth case, pending for three years, was made on May 10, 1984.<sup>15</sup>

#### **Department of Commerce Recommendations**

The recent, three year investigation by the Department of Commerce involved all types of ferrochromium, ferromanganese and ferrosilicon. National Security Council models were used as a basis for stockpiling and mobilization planning. The Federal Emergency Management Agency (FEMA) calculated the requirements for defense production for each ferroalloy from defense mobilization expenditure levels provided by the Department of Defense. Projections were made of the supply of ferroalloys that would be available from domestic production, imports and national defense stockpiles during a national emergency. If total anticipated supply was insufficient to satisfy the projected requirements during each of three conflict years, the short fall in supply was assumed to be a threat to national security.

The investigation has found that imports of two products pose a threat to national security; high carbon ferrochromium and high carbon ferromanganese<sup>10</sup> (South Africa is the primary import source for both). The amount

of supply shortfall is classified.

These products have been subject to foreign price pressure for more than ten years. The investigation found a domestic industry of high technological efficiency able to meet foreign competition were it not for high labor, energy and environmental costs associated with domestic production.<sup>10</sup>

The remedies for HCFeCr that were considered are:

1. Upgrade the national defense stockpile of chromite into HCFeCr to eliminate mobilization short falls.
2. Import quotas on HCFeCr imports.
3. Impose a breakpoint tariff on HCFeCr imports.
4. Impose an import duty on HCFeCr.
5. Take no action.

The primary consideration for policy intervention under Section 232 is to insure the domestic availability of certain products for national defense purposes at the lowest possible cost, and by methods consistent with overall U.S. trade objectives. The option of upgrading stockpiles of chromite and manganese ore into high carbon ferroalloys would best accomplish these goals according to the Department of Commerce. The cost associated with this remedy would be \$33 million per year.<sup>10</sup> Again, this upgrade action was initiated and in effect prior to these findings being made public.

**Presidential Decision**

On May 10, 1984, President Reagan decided that ferroalloy imports do not threaten the United States national security. The upgrade program was adequate and would be continued.<sup>15</sup> This, despite government reports saying domestic ferrochrome production capacity utilization is, and will continue at, 20 percent under this upgrade program.

#### **Interest Groups: The Ferroalloy Association**

The Ferroalloy Association includes twelve member companies producing chromium, manganese and silicon ferroalloys and metals. Members account for virtually 100 percent of the domestic non-captive production of these ferroalloys and metals.<sup>16</sup> What follows is their position on the domestic ferrochrome industry dilemma and its impact on U.S. national security. They present both a "preferred solution" and an "emergency solution" for the problem.

That chromium and manganese are essential to the national security is without dispute. Chromium and manganese ores were some of the first materials to be stockpiled in recognition of their strategic and critical importance to the economy and national security. Today, our stockpile contains over a three-year supply of these materials, mostly as ores, plus a limited amount of ferroalloys. The stockpile conversion program, when completed in ten years, will result in an inventory of

roughly half ore and half ferroalloy. This is desirable from the standpoint of stockpile readiness, but it will be far short in amount and quality to assure the national security. That can be assured only by sufficient domestic capacity to meet emergency demands not covered by the stockpile or met by shipments of imports from distant overseas sources.<sup>9</sup>

Domestic capacity to produce ferroalloys will not be preserved by the stockpile program and must be supported by some form of intervention in the market place to curb the unreasonable low pricing of imports. Increased tariffs, import quotas or orderly marketing agreements are available tools. However, the domestic industry's suggested break-point price system offers a means of accomplishing the desired goals with a minimum of interference in international trade and with little or no objections from our trading partners. In fact, some exporting countries will welcome break-point pricing. Furthermore, the EEC has established minimum import prices for certain ferroalloys and Japan, in its own inimitable way, has restricted imports of selected ferroalloys to preserve their domestic capacity.<sup>9</sup>

The break-point price system, based on costs of efficient domestic producers, would establish a CIF duty declared value for each imported article and impose a severe tariff penalty on any imports below that value.

This type of remedy would not restrict the volume of imports, but would assure fair pricing in the U.S. market and probably in the world market as well, as happened with high carbon ferrochrome in the late 1970's, when break-point pricing was ordered on imports of that product.

Break-point pricing applied to imports of all chromium, manganese and silicon ferroalloys would preserve the capacity of the industry and allow it to continue to modernize its facilities which are, and have been for the most part, as modern and efficient as any in the world. Break-point pricing properly constructed and applied would force certain marginal domestic producers to modernize or close down and ultimately result in domestic industry that will be able to compete in free and fair international trade and stand ready to respond to the nation's needs in an emergency.<sup>9</sup>

As an alternative, emergency solution,<sup>17</sup> ferroalloy capacity to produce any and all ferroalloys can be maintained if domestic production of the major tonnage silicon products--namely 50 percent and 75 percent ferrosilicon--is not permitted to be destroyed by imports. These two products are the "guts" and "backbone" of the ferroalloy industry. The production of all silicon products normally requires over one-half of the existing furnaces and consumes over two-thirds of the electrical power required for full production. Ferrosilicon furnaces

for producing the two tonnage grades account for almost half the existing capacity of the entire industry. Preservation of that capacity to produce these two grades of ferrosilicon will assure furnace capacity to produce such chromium and manganese ferroalloys as will be needed in an emergency. Furthermore, in an emergency, supplies of chrome and manganese ores available from many foreign sources, as well as from the stockpile and even from marginal domestic deposits, can be processed to ferrochrome and ferromanganese.<sup>17</sup>

Since 1970, imports of ferrosilicon containing from 30 to 96 percent silicon (essentially either the 50% or 75% silicon grades) have risen from 0 percent in 1970 to over 54 percent of the domestic market today, as indicated in Table IV-4. These two products can be produced interchangeably in the same furnaces and are equally interchangeable in use for iron and steel production with price being the major consideration by the user. To date, imports have been largely of the 75 percent grade for reasons of economy in shipping silicon units and certain safety problems which are now being overcome in the overseas shipment of the 50 percent grade. It is expected that imports of the 75 percent grade will continue to dominate the market but imports of the 50 percent grade can be expected to grow, especially from South American producers such as Brazil and Venezuela.<sup>17</sup>

If domestic capacity to produce ferroalloys is to be preserved, prompt and effective action to reduce the volume of ferrosilicon imports must be taken. Such actions may include quotas, increased tariffs or orderly marketing arrangements. A suggested measure to relieve the price pressure from imports would be the break-point duty similar to that so successfully used for high-carbon ferrochrome several years ago. The break-point duty concept is particularly attractive and appropriate as it relieves the pressure low-priced imports exert on the domestic producers' profitability and does so without imposing restrictions on the volume of imports.<sup>17</sup>

The cost of implementing a break-point duty system can be estimated from usage in steel at 2.5 pounds of silicon per ton of steel production and in iron at 15.0 pounds per ton of castings shipped. An increase of ten cents per pound in the average price of silicon would cost the steel industry less than 25 cents per ton of steel production and the iron castings industry less than \$1.50 per ton of castings shipped. Total cost to the economy in 1981 would have been about 25 million dollars and in 1982 about 15 million dollars--a small cost, indeed, for preserving an essential industry and, moreover, a much smaller cost than the necessary stockpiling would be in the absence of a domestic industry. In fact, a full stockpile of chromium, manganese and silicon ferroalloys

would cost over 2 billion dollars to put in place.<sup>17</sup>

In short, ten consecutive calendar quarters of financial loss<sup>9</sup> and the probability of continued high imports in the future paints a dismal picture. Government intervention is needed now if any semblance of the industry is to survive.

Since those solutions were proposed by the Ferroalloy Assoc., the President made his decision discussed earlier. Upon the writing of this thesis, the Ferroalloy Association is "licking its wounds", realizing they seem to be out of options at the present time. Individual members must decide how to best "ride out" their industries economic adversity with little or no government assistance.

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## CHAPTER IV

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## CHAPTER V

### GEOPOLITICS OF THE WORLD'S MAJOR CHROMIUM PRODUCERS

#### INTRODUCTION

This chapter takes a look at the major chromite, and especially ferrochrome, producers of the world. Their industry structure, chromium production advantages and disadvantages, and their political situation as it relates to the United States are key considerations. This is part of the process that helps U.S. policy makers and industrial consumers of chromium make decisions about diversifying imported sources of chromium to combat security of supply vulnerabilities.

(6) This author is indebted to, and gratefully acknowledges, Captain Kent H. Butts, Assistant Professor, Department of Geography, United States Military Academy, West Point, New York. He provided me with much of the source material used in this chapter and his work is referenced throughout the chapter.

#### THE REPUBLIC OF SOUTH AFRICA

How is it that South Africa has been able to develop such an imposing position in the world ferrochromium market in such a brief period? Many factors account for South Africa's comparative advantage. In comparison with ferrochromium produced in countries utilizing high-chromium chromite, South Africa's ore is in itself an advantage.

In this era of the AOD process, the former advantages inherent to ferrochromium produced from high-chromium ores, such a greater chrome content and reduced carbon, are no longer salient. Indeed, it could be argued that the South African ferrochromium offers a highly suitable package for stainless steel production. The lower chromium content of South Africa's ferrochromium is not a major disadvantage. The pure iron which comprises the balance of the ferrrochromium's content is a necessary component of stainless steel which would otherwise be added from scrap steel. Such a substitution reduces the amount of contamination from impurities such as copper and lead, typically present in the scrap.<sup>1</sup>

The high carbon content is also beneficial. Normally scrap added to the bath must be melted by the use of expensive electric power. However, during the exothermic reaction of the argon/oxygen blow, carbon serves as the fuel. Thus, the high carbon presence may lift temperatures to as high as 1750 C. Such temperatures could damage the container. Therefore, scrap is added at this point to cool the bath. This procedure obviates the need to melt the scrap via supplemental electric heat. In addition, fines from low-chromium ores such as those in South Africa are: less difficult to melt, more reactive and easier to agglomerate than fines from high-chromium ores in Zimbabwe, Turkey and Russia.<sup>1</sup> However, the

adaptability of South Africa's chromite to new stainless steel technology does not alone account for that country's preeminent position in the ferrochromium market.

South Africa's ferrochromium industry has benefited from a certain momentum arising from the previous concentration of chromite mining interests in and around the Pretoria - Johannesburg region. To this preexisting infrastructure the South Africans have added a series of ferrochromium plants which rival any in the world.

The cost of constructing ferrochromium processing facilities is enormous, and could well be viewed as a constraint to further development of ferrochromium plants in other chromite ore producing countries.

The submerged arc electric furnaces in which ferrochromium is smelted vary in size of power connection output from 7 to 60 Mw. In 1975, the price of constructing such smelters was between \$870,000 and \$1.3 million per Mw of furnace output. This figure does not include any major accompanying infrastructure.<sup>2</sup>

The larger furnaces built in the last decade offer better economic efficiencies than do their smaller predecessors. Furnaces above 25 Mw typically require 3.6 to 3.8 Mw hours per ton of product with some of the more sophisticated smelters requiring only 2.8 Mw hours per ton. Modest size furnaces, such as those in the 8 to 10

Mw range will consume more electricity per unit of output. An 8 Mw furnace for example, may well consume 4.4 Mw hours of electricity per unit of output.<sup>3</sup> Currently, South Africa has an installed furnace capacity of 540 Mw in its ferrochromium industry. This figure represents some 50 percent of the known world total for the export of ferrochrome and related alloys in the world.<sup>4</sup>

#### **Chromite/Ferrochrome Industry Structure**

Most of the mineral industries in South Africa, including chromite and ferrochrome, are privately owned by members of the Chamber of Mines of South Africa through one or more of the six multinational mining houses collectively responsible for the development of much of the mineral industry in southern Africa: Anglovaal Ltd. (AVL), Anglo American Corp. of South Africa Ltd. (AAC), Barlow Rand Ltd. (BRL), General Mining Union Corp. Ltd. (Gencor), Gold Fields of South Africa Ltd. (GFSA), and Johannesburg Consolidated Investment Co. Ltd. (JCI).<sup>5</sup> Tables V-1 and V-2 provide a sketch of the South African chromite and ferrochrome producers, respectively. The following ferrochrome company description augments these tables.

Tubatse Ferrochrome Ltd. began producing in 1976. Union Carbide provides the technology and management expertise while the ore to be smelted originates in Gencor's nearby Montrose and Groothoek mines.<sup>1</sup>

TABLE V-1  
STRUCTURE OF THE SOUTH AFRICAN CHROMITE MINING

<u>Major Operating Companies</u>	<u>Location of Main Facilities</u>	<u>Rated Capacity (1000 tpy)</u>	<u>% SA output</u>
(Country)(Ownership %)			
Lavino South Africa(Pty.) Ltd.; (USA)(International Minerals & Chem. Corp.100%)	Grootboom, Tvl. (near Lydenburg)	300	10
SAMANCOR, Grasvally, Mooinooi,& Ruighoek Mines. (SA)(IDC-45%) (AAC-30%)	Pietersburg (W. of Gravelotte) Rustenburg, both in Tvl.	500	15
Transvaal Consolidated Land & Exploration Co. Ltd., Henry Gould, Milsell,& Winterveld Mines (SA)(BRL-67%)	Kroondal (near Rustenburg), Steelport (near Lydenburg),& Driekop (near Lydenburg), all in Tvl.	1000	30
Transvaal Mining and Finance Co. Ltd., Groothoek, Hendriksplaats, & Kroondal Mines (SA) (Gencor-100%)	Kroondal, Tvl. (near Rustenburg)	1000	30

**Abbreviations:**

SAMANCOR: South Africa Manganese Amcor Ltd.; IDC: Industrial Development Corp. Ltd.; AAC: Anglo American Corp. of South Africa Ltd.; BRL: Barlow Rand Ltd.; Gencor: General Mining Union Corp. Ltd.

Source: 5

**TABLE V-2**  
**STRUCTURE OF SOUTH AFRICAN FERROCHROME INDUSTRY**

<u>Company</u>	<u>Ownership (Country)(%)</u>	<u>Ore Transport Distance</u>	<u>SAF's(Mw)</u>	<u>Rated Capacity (1000tpy)</u>
Tubatse	Gencor (SA) (51%) Union Carbide (USA) (49%)	20 km	3x30	120
CMI	AAC (SA) (25%) JCI (SA) (53%)	119 km	2x32.5	140
Ferroalloys Ltd. Chrome Section	AVL+ (SA) (69%) USS (USA) (31%)	5 km	3x24 2x12	116
RMB Alloy Inc.	BRL (SA) (100%)	6 km	2x25 3x7.5 1x4.5	140
Palmiet Chrome Corp. Ltd.	BRL (SA) (100%)	7 km	1x11,14,20	70
Ferrometals Ltd.	SAMANCOR (SA) (100%)	na	1x15,25 2x48	250

**Abbreviations:**

SAF: Submerged arc electric smelting furnace; Tubatse: Tubatse Ferrochrome Ltd.; Gencor: General Mining Union Corp. Ltd.; CMI: Consolidated Metallurgical Industries Ltd.; AAC: Anglo American Corp. of South Africa Ltd.; JCI: Johannesburg Consolidated Investment Co. Ltd.; AVL+: Anglovaal Ltd. and Associated Ore and Metal; USS: United States Steel Corp.; BRL: Barlow Rand Ltd.; SAMANCOR: South African Manganese Amcor Ltd.

Source: 1,5

The Consolidated Metallurgical Industries Ltd. (CMI) plant has been designed for future expansion of smelting capacity. Because the facility has its own pelletizing and prereduction kilns, an annual capacity of 140,000 tons may be reached utilizing the two 32.5 Mw furnaces while the Tubatse plant must use three furnaces of 30 Mw each to reach a similiar output. Chromite is railed from the Winterveld and Lavino chrome mines to CMI.<sup>1</sup>

The ore for the Ferroalloy Ltd. operation is generally the high-chromium chromite mined from the Zeerust mines of Nietverdiend in western Transvaal. The high grade ore enables Ferroalloy to diversify its product mix to include low-carbon ferrochromium as well as charge chrome. Plans are underway to install a fourth 24 Mw furnace when market dictates.<sup>1</sup>

Various Barlow Rand mines in the area provide a mixture of ore types that enables RMB Alloy Inc. to produce all types of ferroalloys. Vertically integrated with Middelburg Steel and Alloys Ltd., RMB is developing plasma ferrochrome production technology in cooperation with the South African Council for Mineral Technology (Mintek). A pilot furnace is to be commissioned soon. By converting its furnaces from the conventional submerged electric arc (SAF) type to the plasma type, Middelburg could double its ferrochrome production capacity.<sup>6</sup> The

new technique will be able them to use both coarse and fine chromite and coke, and is expected to have a lower cost per ton of product than orthodox methods of ferrochrome production.<sup>7</sup>

Middelburg Steel and Alloys also produces corrosion-resistant 3CR12 steel (an alloy steel of 0.03% carbon, 0.6% nickel, and 12% chromium content) for its home market and was negotiating licensing production to foreign steel producers. 3CR12 steel is designed to fill the gap between rust-prone carbon steel and conventional stainless steel, which costs three times more than carbon steel. This new corrosion-resistant alloy steel requires little or no maintenance. The cost advantage of 3CR12 is reflected in the fact that in mining applications (such as chute liners), its lifespan is 10 times that of carbon steel yet less than double the price. However, the U.S. mining industry is in such bad shape that no money is available to purchase the steel.<sup>6</sup>

Meanwhile, South Africa is expected to use 3CR12 on its power towers and electric rail system. If successful in replacing other alloy steels, 3CR12, because of its higher chromium content, will increase ferrochrome consumption.<sup>7</sup> The acquisition of even a one percent share of the world carbon steel market would double ferrochrome production.<sup>8</sup>

Palmiet Chrome Corporation Ltd., like RMB, is

owned in its entirety by Middelburg Steel and Alloy Ltd., a part of the Barlow Rand Group. One of two original ferrochrome producers in South Africa, it's also the smallest and the only one lacking direct access to rail lines. The ore, which originates at the Millsell, Winterveld and Henry Gould mines, and the final ferrochromium product, must be trucked 7 km to the Krugersdorp railyard.<sup>1</sup>

Ferrometals Ltd. incorporates the latest technology into its smelting process. Ore is trained indirectly from the 3 Samancor mines listed in Table V-1. The plant has its own briquetting for the reduction of fines, but new smelting techniques developed by Ferrometals allows the use of fines directly without costly briquetting. Two new, computer controlled, 48 Mw furnaces make them South Africa's largest producer.<sup>1</sup>

It is interesting to note the degree to which the Mining Houses of South Africa control the production of ferrochromium. In no plant does a foreign corporation have controlling interest, the closest being Union Carbide's 49 percent share of the Tubatse facility. Indeed, the only meaningful, "non Mining House" penetration of the industry has been b. Samancor and this, also may prove to be ephemeral. In 1977, the government controlled steel corporation Iscor, which held 45 percent ownership in Samancor, began to divest itself of non-

essential holdings. Samancor's stock fell into that category and three companies bid for the sizeable share of its ownership; Anglo-American (AAC), Barlow-Rand and Gencor. When it was determined that AAC was the highest bidder, the government halted the sale.<sup>9</sup> Mineral industry experts believe that AAC's already dominant position in the South African mining industry caused the government to act in order to prevent an imbalance in the industry. However, it should be noted that the chairman of AAC, Harry Oppenheimer is "an outspoken critic of government race politics" and the control of South Africa's largest ferrochromium producer might have, in the view of the government, given Mr. Oppenheimer too much leverage.<sup>9</sup> In the intervening years, AAC acquired 14 percent of Samancor on the open market and in 1982, gained seven million shares and an additional 16 percent when it sold Samancor the Middelplaats manganese mine.<sup>10</sup> However, the AAC bid fell short when, in June 1983, GENCOR succeeded in gaining control of Samancor, thereby placing the two preeminent ferrochromium plants; Tubatse and Ferrometals under the same corporate roof.<sup>11</sup>

Thus, one finds the South African ferrochromium industry in a strong position in terms of both infrastructure, management and capitalization. Controlled by the wealthy South African Mining Houses, the industry is well capitalized and therefore able to weather lean

financial periods. Moreover, these dependable sources of capital have insured the acquisition of the most modern and efficient smelting facilities capable of realizing important economies of scale. In addition, the parent companies have provided forward and backward linkages, establishing a de jure form of integration; ore from Mining House mines processed in Mining House smelters for use in Mining House steel works. In terms of situation, the South African ferrochromium industry enjoys a comparative advantage over its competitors.

#### **Comparative Advantages**

When one considers the factor inputs required for the production of ferrochromium, one would find it difficult indeed to select more advantageous sites for ferrochromium smelters than those selected by the South Africans. With the exception of the Palmiet facility, the smelters are situated to take maximum advantage of the Transvaal's enormous deposits of coal and chromite as well as the well-developed transport infrastructure.

South Africa's comparative advantage in factors of production for the mineral industry has been elaborated upon elsewhere. However, in the specific case of ferrochromium, it is worth noting that five of the energy intensive smelting plants are located adjacent to the Steelport chromite producing area and the Witbank Coal Fields of the Southeastern Transvaal.<sup>7</sup>

### Energy Costs

Energy costs have become a major constraint to domestic minerals processing in many of the industrialized countries. In Japan, where a large percentage of electrical supply is oil based, rising petroleum prices have markedly reduced the competitive position of the ferrochromium sector and resulted in the elimination of much of their industry.<sup>1</sup> Japanese ferrochromium producers must now pay 60 mils for electrical power.<sup>11</sup> The explanation for Europe's exit from the ferrochromium market is at least partially explained by the sizeable difference between the power rates charged large consumers in the Federal Republic of Germany (FRG) and those of South Africa. Producers in the FRG were charged 4 to 6 pfennings/kwh while the South African rate was 1.5 to 2 pfennings/kwh.<sup>2</sup> It is noteworthy, then, that South Africa's smelters are adjacent to coal reserves estimated at 110 billion tons where large pit-head generating plants produce 90% of South Africa's power.<sup>1</sup> Moreover, the Electricity Supply Commission of South Africa's integrated national power grid, and long term planning based upon an "at cost" philosophy, guarantees secure power supplies at a reasonable cost. This is especially important in that, "power costs account for the highest share in the processing costs."<sup>2</sup> Rather than a constraint, energy costs have proven an impetus to development of

ferrochromium capacity in South Africa.

#### **Mine Site Processing Savings**

South Africa does benefit from a well developed electrical power industry, but there are other economic reasons which account for the viability of the country's ferrrochromium industry. Arguably, the most important advantage is the cost savings inherent in mine-site metals processing.

The ability to process chromite into its ferrochromium form reduces transportation costs for processors located in South Africa. Further, South African producers may also acquire raw materials at less cost. To explain the latter, one need but examine the price differentials for raw materials between a European producers and those in South Africa. Coke, used as a reductant in the melt, was available to smelters in the FRG (Germany) for 250 Deutsche Marks (DM) per ton at the same time the coke price for South African smelters was only 105 DM per ton, a difference of approximately 58 percent.<sup>2</sup> Ore costs exhibit a similar pattern. South African smelters obtained ore at a price of 80 DM per ton while shipping and handling charges had inflated the price to 150 DM per ton by the time it was received at the FRG's smelter.<sup>2</sup> Coupled with the higher power costs of the industrialized country processor, the premium price paid for raw materials is a severe obstacle on the road to

profitability.

#### **Transportation Costs**

Profitability, in fact, is the key to the locational analysis of South Africa's comparative advantage. Weber's theory of plant location offers an appealing framework for summarizing such an analysis. Weber theorized that the "purity" of a raw material governed the location of manufacture or processing. A raw material which was pure, that is to say the full weight of the raw material was productively utilized in the finished product, could be processed at any point between source and market with equal benefits, all things being equal. However, a raw material which lost weight during processing should, in general, be processed at or near its point of production to minimize transport costs.<sup>12</sup>

In terms of chromite ore processing, 2.5 tons of chromite ore are required to produce one ton of ferrochromium. The weight loss ratio is, therefore, .6. This would indicate an advantage in processing the ore near its source to prevent the need to pay transport charges on 1.5 tons of gangue. Moreover, South African chromite sells for \$55 per ton in the U.S. while the processed ferrochromium will sell for between \$370 and \$470 based on chrome content.<sup>1</sup> Thus, the value added by processing is now a realized profit for South African producers.

Weber realized that theoretically optimized, locations based on transport costs could be distorted by such variables as the price of labor. Labor cost savings, which offset the benefits of transport cost differentials, could in fact lead to the determination of another optimum location.<sup>12</sup> As regards the South African labor situation, such is not the case. Significantly, ferrochromium plant labor costs may account for up to 15 percent of total costs.<sup>2</sup> The industrialized nations have witnessed a spiraling of labor wages in the wake of increased unionization and competition for increasingly scarce human resources. South Africa, with a surplus indigenous unskilled labor and a steady supply of foreign workers, has a distinct labor cost advantage over the industrialized nations in that the wages in South Africa are much lower.

While South Africa currently holds a position of leadership in world ferrochromium exports, it is not the only supply source. Ferrochromium capacity is spatially dispersed around the globe. Other chromite producing nations have entered the downstream market by processing the mineral and becoming new sources of ferrochromium supply. In order to properly evaluate the strategic nature of U.S. dependence upon South African producers, it is necessary to examine the viability and dependability of alternative sources of supply. Inasmuch as the EEC and

Japanese industries are waning and are known chiefly as domestic suppliers, they will not be discussed.

#### **ZIMBABWE**

The size of the stratiform chromite deposits of the Great Dyke plus podiform chromite deposit near Selukwe are huge. Some mineral analysts suggest that the known or hypothetically determined resources of ore may be considered a viable alternative to dependence upon South Africa. However, this notion depends on its corollary, the idea that large ore reserves beget a competitive ferrochrome industry.

As discussed previously, Zimbabwe's chromite resources are quite large. The ore contained in the Great Dyke alone is estimated at up to 11 billion tons.<sup>13</sup> While the economic viability of mining the totality of the ore is highly doubtful, there is little doubt that reserves sufficient to maintain, and even improve, Zimbabwe's current status as an exporter of ferrochromium do exist.

The infrastructure with which to service Zimbabwe's ferrochromium industry is locally well developed, owing to the long-term existence of a metals processing industry and the relatively well-developed state of the economy.

#### **Chromite/Ferrochromium Industry Structure**

Looking at Tables V-3 and V-4, note that Zimbabwe's chromite mining and ferrochrome production are

TABLE V-3  
STRUCTURE OF ZIMBABWEAN CHROMITE MINING

<u>Major Operating Companies (Country)(Ownership %)</u>	<u>Location of Main Facilites</u>	<u>Rated Capacity (1000tpy)</u>	<u>% Output</u>
Zimbabwe Mining & Smelting Co. (USA) (Union Carbide 100%)	Mtoroshanga Selukwe	1000	70
Zimalloys (SA)(Anglo Amer. Co.100%)	Siwoia	400	30

Source: 5

TABLE V-4  
STRUCTURE OF ZIMBABWEAN FERROCHROME INDUSTRY

<u>Company(Ownership) (Country)(%)</u>	<u>Saf's (Mw)</u>	<u>Rated Capacity (1000tpy)</u>
Zimbabwe Mining & Smelting Co. (USA) (Union Carbide)(100%)	1x7.5,12.5 2x15 2x24	170
Rhodall Ltd. (Anglo-American Corp.) (SA)(100%)	1x5.5,6.5,8 3x15 1x30	180

Source: 1,5

both controlled by two foreign giants; the Anglo-American Corp. of South Africa (AAC), and the Union Carbide Corp. of the USA.

Rhodal Ltd., formerly Rhodesian Alloys Ltd., is a subsidiary of ACC and operates at Gwelo. Their largest furnace, a 30 Mw SAF was added in 1981. Since then, plans to add three new furnaces were abandoned because of high production costs. In 1982, Rhodall reported \$1 million in lost production owing to carelessness, lack of effort, and poor timekeeping, as well as \$1 million of equipment repair that should have been unnecessary. Labor problems were also encountered owing to new labor leaders and noncooperative worker committees.<sup>7</sup>

Zimbabwe Mining and Smelting Co., the Union Carbide subsidiary, typifies the problems associated with production in the countries of sub-Saharan Africa (apart from the Republic of South Africa). The plant, at QueQue, is modern, well-managed and well-integrated. The two 24 Mw furnaces were installed in 1982 and are the highly efficient Tagliafelli submerged arc model.<sup>7</sup> In spite of skilled management, integration and modern infrastructure, the Zimbabwe Mining and Smelting Co. incurred losses of \$1.4 million in 1982.<sup>1</sup> The world economy was not the salient cause.

#### **Bureaucratic Intervention Disadvantages**

Government intervention in the economy in general,

and the minerals industry in particular, has severely effected the profitability of the ferrochromium industry, as noted below. The two areas in which government action has proven most critical are wages and interest rates.

#### **Wages Increases**

Enacted in 1980, the minimum wage law, has mandated wage increases in the mineral industries. Companies have reported the total expenditure on salaries accounting for as much as 55 percent of total costs.<sup>1</sup> At Zimbabwe Mining & Smelting, the degree to which salary increases for workers has affected profitability borders on the unbelievable. The following quote by Mr. G. A. Carey-Smith, Chairman of Zimbabwe Mining & Smelting, reflects the degree to which the Mugabe government has penetrated the public sector to improve the economic situation of black workers.

The main problem...continued to be the escalation of costs. I have reported in the past that because of the narrow seams in the Great Dyke deposits, chrome mining in Zimbabwe is a labor intensive operation and increases in wages have a more marked effect on the cost of the finished product than they do in most other chrome producing countries. We have now reached a position where it would be as cheap for us to import chrome ore from overseas as to mine it from Great Dyke deposits.<sup>14</sup>

Losses due to labor are not entirely related to salaries. In the wake of the governmental takeover by the Mugabe administration, a breakdown in industrial discipline has occurred. In nine months, Zimbabwe Mining

& Smelting lost approximately \$1 million in production at the QueQue refinery due to carelessness and lack of effort on the part of workers. Management efforts to correct this problem within the Marxist system have met with strong resistance. Workers committees are condemned by peers as "sell outs" when they are perceived as working with management.<sup>1</sup>

#### **Interest Rate Increases**

Zimbabwe Mining & Smelting was further injured by the government's second increase in interest rates. Occurring in conjunction with a recession-based decline in world ferrochromium prices, the doubling of Zimbabwe's interest rates within a seven month period raised interest charges from \$2.5 million in 1981 to \$4.8 million in 1982 and to an estimated \$8 million in 1983. Interest rate increases alone added \$4 million to 1982 losses.<sup>2</sup> Can one realistically expect a producer forced to operate under such economic constraints to realize a gain in production or market share or in any way threaten the dominance of a vital South African smelting industry operating in an environment designed to foster capitalism?

#### **Energy Question Marks**

Most of Zimbabwe's electrical power is hydroelectric. Two plants along the Zambezi River (the border between Zimbabwe and Zambia) supply 90 percent of the country's supply. However, part of this power

belongs to Zambia. Indeed, 30 percent of Zimbabwe's power is imported and cannot, in the long term, be considered secure. Yet, the mining industry consumes 20 percent of the country's total power supply and in 1980, when only 150,000 tons of product was produced, the ferrochromium industry consumed 10 percent of Zimbabwe's total electrical output. Two thermal plants taking advantage of the sizeable domestic coal reserves at Wankie will come on line shortly. Wankie I, (480 Mw) will begin operation this year while Wankie II, (800 Mw) is expected to start up in 1986. Nevertheless, if demand for consumption increases at an annual rate of 10 percent, as it has for the last decade, and Zambia reclaims its Zambezi River power to satisfy its own growing domestic demand, Zimbabwe could theoretically incur an energy deficit of up to 5 billion kilowatt hours by 1990.<sup>1</sup> This lack of electrical power availability may cause the curtailment of capacity expansion in the ferrochrome smelting industry.

#### **Port Problems**

Zimbabwe may have energy resources but it does not have ports. Landlocked, the country must depend upon the efficiency and good will of its neighbors to export chrome products. With the exception of its ideological enemy South Africa, neither trait is present. Mozambique's ports of Beira, Maputo, and the Tazara rail line from Zambia to Dar es Salaam are case studies in mismanagement

and inefficiency. Thus, Zimbabwe depends upon South African rail and port infrastructure for 90 percent of its exports and imports.<sup>1</sup>

#### **Government Policy Problems**

Perhaps the most pervasive factor in determining Zimbabwe's future chromite production is the government. Prime Minister Mugabe has brought a Marxist philosophy and a history of antiwestern rhetoric to government. Although surprisingly even-handed and pragmatic, his emphasis on higher wages for chromium industry labor and the establishment of the Minerals Marketing Board have caused a "wait and see" approach among producers of chromite and ferrochrome. According to Dr. Fine, foreign investors, disappointed in Mr. Mugabe's lack of assurances, are reluctant. Should this pattern continue the economy could be weakened to a point where Zimbabwe might be forced into bartering its ferrochromium to the East.<sup>15</sup> New smelters and mines, which must be developed in the Great Dyke, will require substantial capital investment which the government cannot provide.

Compounding the problem is the ongoing ill will between Mr. Mugabe and the former Home affairs Minister Nkomo, and guerilla attacks against such targets as the Zimbabwe Air Force. The potential for violence from such events has caused a lack of confidence among the skilled white population and an exodus of over 1/6th of their

numbers since independence.<sup>1</sup> Moreover, if Mr. Mugabe is unsuccessful in his efforts to halt this political unrest and satisfy the needs of Mr. Nkomo's followers, major fighting and a further weakening of the economy could occur.

While, Zimbabwe has the chromite resources to satisfy ferrochromium demand in the long run, the dependability and further expansion of ferrochromium supplies in the near future are not assured. The questionable economic nature of its stratiform ore deposits, dependability on its ideological enemy South Africa for product transport, and the negative aspects of government policies for the manufacturing sector cast serious doubt upon the reliability of Zimbabwe as a secure source of ferrochromium in the short term.

#### TURKEY

Famous as a supplier of chromite to the Germans during World War II, Turkey has long been synonymous with the export of chromite. Now, the country wishes to expand its metals processing sector to reap the added value benefits accruing to ferrochromium producers.

The leading force in Turkey's drive for a large share of the world ferrochromium market is Etibank (government owned), which dominates the country's smelting production. The company currently operates a 10,000 ton-per-year low-carbon facility and 50,000 ton-per-year high-

carbon plant near Elazig in eastern Turkey. The latter facility is scheduled for expansion to 100,000 tons, which will give the State control of an annual capacity of 110,000 tons. Designed by Japanese Metals and Chemicals Corporation and financed by Etibank, Finland's Outokumpu Oy and Norway's Elkem, the Elazig smelter is approximately 35 Km from the Kef mine from which it derives its ore.<sup>7</sup> Turkey is fortunate to have a large potential for hydroelectric power. The viability of its expanded ferrochromium industry is no doubt enhanced by such projects as the new Keban dam, harnessing the upper Euphrates River.<sup>13</sup> While ore and energy inputs seem adequate, one must consider other variables which impact the security of Turkish ferrochromium supply.

The perennial source of power in Turkey is the Military. Civilian rule is accepted and tolerated until the Military perceives that its failures are threatening the national security, at which time the Military assumes control. Currently, under General Evren, the government is realizing success in dealing with the nation's problems of violence, assassinations, and a poorly managed economy. Yet, challenges remain; other ongoing internal problems are high unemployment, overpopulation, a large national debt and the reestablishment of civilian rule.<sup>1</sup>

Geopolitically, Turkey is virtually surrounded by hostile or unstable regimes. To the south, Soviet backed

Syria and the Military ruled, belligerent Iraq abut Turkey's borders. The Western flank is bordered by the Soviet states of Georgia and Armenia and the highly unpredictable, anti-Western Iran, currently at war with Iraq. In the west, Turkey must contend with the conflict over territorial claims and long term hostility from its historical adversary, Greece. At present, none of these states pose a serious threat to Turkey's survival, however, the potential is significant. Indeed, the willingness of Turkey's three southern neighbors to use their military forces has frequently threatened the stability of the entire Middle East.

Although an ally of the West with a strong central government, Turkey faces ongoing internal political and economic problems and the constant threat of conflict on its borders. Sitting as it does astride the trade routes to the Black Sea, Turkey is a natural target for Soviet interference. Based upon these factors, one must be concerned about the security of Turkey's modest ferrochromium exports. Turkey is a natural target for Soviet destabilization. Combining this potential for political instability with Turkey's expansion into the downstream area of ferrochromium production leads one to logically question the security of chromite supplies from this country.

**BRAZIL**

Brazil is the only ferrochrome producer in South America. The chromite is mined 300 Km northwest of the port of Salvador in the disrupted stratiform deposits of Bahia. The discontinuous nature of the chromite seams makes reserve estimates difficult and accounts for the inconsistency of estimates such as 5.5 million tons in 1982, 2.2 million tons in 1980, and 10 million tons in 1976.<sup>16</sup> Ores are trucked to the railhead at Campo Formosa for export via Salvador or shipment to the ferrochrome processing center at Ponjuca. The ferrochrome smelter has a capacity of 110,000 tons per year of which all but 20,000 tons are exported to Japan, Europe, the U.S. or Canada. The privately owned Ferbasa company, dominates Brazilian chromite mining and accounts for all ferrochromium production.<sup>7</sup>

Ferrochromium production in Brazil has been rising but could well be constrained by Brazil's lack of energy resources. Coal imports totalled \$34 million in 1979. Brazil also imports 750,000 bbl of oil daily.<sup>17</sup> The recently completed \$18.5 billion Itaipu hydroelectric facility in the south will divert its power production to Sao Paulo.<sup>17</sup> However, Brazil currently subsidizes the cost of electricity to its ferroalloys industry. The subsidy lowers the power rate from 25 mils to 10 mils for export products. Whether such a subsidy can be continued in the face of a crushing national debt remains to be

seen.<sup>18</sup>

Brazil has been ruled by the Military since 1964; political unrest is not a major problem. The major problem of this developing nation is the \$80 billion national debt, largely the result of its' dependence on foreign oil and the correspondingly high rate of inflation (100 percent). In spite of this, the government is drawing substantial investment capital from foreign sources to take advantage of its plan to expand the mineral processing industries.<sup>7</sup>

Brazil is not plagued by the revolutionary turmoil so prevalent in other South American countries, nor is it bordered by aggressive or hostile nations capable of its overthrow. Well-sited in the umbrella of U.S. hemispheric security, Brazil has little to fear from geopolitical turmoil. Philosophically anti-Communist, relatively stable politically, and boasting a solid infrastructure and resource base, Brazil is the most secure of all suppliers shipping chromium products to the West. While, it has, as yet, a relatively modest ferrochromium capacity, an expanded, aggressive program of chromite exploration and hydroelectric development may well enable Brazil to one day develop into a significant alternative to South African ferrochromium supply. This could increase U.S. supply security due to Brazil's closer locale and enhance the diversification of supply sources

for ferrochrome.

#### **FINLAND**

Attention has been focused upon the Scandinavian country of Finland as a possible source of expanded ferrochromium supply. The basis for such thinking are the sizeable chromite deposits recently discovered in the Kemi area.<sup>13</sup> Why could these resources of high iron stratiform chromite, the same type found in South Africa, not generate a large, viable smelting industry on which the industrialized nations could depend?

As shown in Table III-2, Finland's chromite reserves are the world's fourth largest at some 28 million tons. The fully integrated steel manufacturer Outokumpu Oy (government owned) conducts every aspect of its operation, from mining to smelting to stainless steel production within a radius of 40 Km. The bulk of chromite exports, over 300,000 tons, are shipped to the U.S. and Sweden while the remainder is utilized in stainless steel production.<sup>7</sup>

Ferrochromium is produced at Tornio. Smelting is accomplished in a 24 Mw submerged arc furnace which in 1978 produced 45,000 tons. This furnace has been expanded to 35 Mw with a corresponding rise in product capacity to 60,000 tons per year. The ferrochromium produced at Tornio is utilized in the Finnish stainless steel industry and is not produced for export.<sup>7</sup> It is thought that

Finland's lack of energy resources (85 percent of its energy is imported) is a major constraint to the development of an export-oriented ferrochromium industry. It is strategically important to note that 60 percent of Finland's energy imports originate in the Soviet Union.<sup>1</sup>

Internally, Finland demonstrates unusual stability. Its civilian political system has a long history of success in domestic and international issues. The Finnish economy is one of the fastest growing in the world. Highly diversified, the economy now boasts dynamic metals, engineering, chemical and textile industries to complement the once dominant agricultural and forestry sectors. The Soviet Union now accounts for 20 percent of Finland's total trade.<sup>1</sup>

Geographically, Finland is much less secure, as it shares an 800 mile long border and a history of conflict with the Soviet Union. The impact of this relationship on the decision making and international behavior of Finland cannot be overestimated. Indeed, Finland is known as a country so frightened by Soviet power that it is no longer able to control its own foreign policy.<sup>1</sup> To think that the Soviet Union could not coerce the Finns to alter their chromium marketing patterns in time of emergency would be naive. Were military force to be disregarded, the Soviets would still enjoy substantial influence over Finland vis-a-vis its dominant energy supply position. Thus, in spite

of relatively large chromite reserves, the lack of energy resources and its sensitivity to Soviet demands makes Finland a marginal source of ferrochromium exports and a non-secure supplier of chromite to the West.

#### **PHILIPPINES**

Although well-known as a source of high-aluminum chromite, the Philippines has conservatively estimated reserves (3.3 million tons) which belie an apparently sizeable volume of metallurgical grade ore as well. With one-quarter of Philippine production now accounted for by metallurgical grade chromite, metal processing firms are showing an interest in establishing ferrochrome operations in the Philippines.

The West German firm of Bayer AG is planning a chromite processing plant on Iamar Island. The plant will eventually have a capacity of 100,000 tons. Ore for the plant will be mined from Iamar Island's 1.9 million ton deposits, and all production will be used by Bayer AG in its own steel making operations.<sup>1</sup> Voest Alpine will complete its \$70 million ferrochromium smelter at Misamis Oriental this year which will have an annual capacity of 50,000 tons. The smelter will use ores from the Acoje mine and may be expanded to a capacity of 120,000 tons per year. Voest Alpine will utilize 25 percent of output while the remaining product will be exported to Mainland China.<sup>1</sup> In addition, the Philippine company, Ferro

Chemicals, has opened a 7,500 Mw smelter on Mindanao Island. Annual high-carbon ferrochromium production will be 12,000 tons.<sup>7</sup>

These operations demonstrate the trend of producing ferrochromium at the mine site, although it would appear integrated firms are the only producers capable of economic production in the Philippines. While rich in ore deposits, the Philippines are energy deficient. Nominal coal production and a lack of emphasis on hydro development have forced the nation to produce most of its power from imported fuel oil. The resulting high cost of electricity has served to constrain the mining and metal processing industries.<sup>1</sup>

The Philippines have never enjoyed total political stability; the ongoing Muslim revolt on Mindanao is but a continuation of historical unrest. President Marcos, having established martial law and an unlimited term of office, appears capable of containing this instability. Moreover, his wife has developed a solid political base of her own and, given her experience as Governor of Manila, should have been able to successfully succeed her husband in office.<sup>1</sup> However, recent indications of cleavages among Marcos' inner circle and the assassination of opposition leader Benigno Aquino Jr. have lead analysts to suggest the Marcos regime has lost some power. While the rash of demonstrations have

shown Marcos lack of popularity, they have not been anti-Western in nature.

Geopolitically, the Philippines may be considered relatively secure. Its insular nature separates the country from its potential adversaries such as Vietnam, and the largely rhetorical conflict with Malaysia over Philippines claims to Sabah has been allowed to abate. The Security of a strong U.S.-Philippines relationship remains in part due to the insistence of China that the U.S. not be forced out of their sizeable naval bases on the Islands. Such a departure, the Chinese fear, could invite adventurism on the part of the expanded Soviet naval forces based in Vietnam.<sup>19</sup>

Given the history of a pro-Western political orientation, its pragmatic relationship with the Chinese and a continued U.S. military presence, the future of the Philippines appears most stable.

The positive attitude with which the country welcomes foreign participation in the minerals industry, and its growing reserve estimates, indicate a scenario of marked dependability in the future supply of chromite ore. However, the energy deficit and resulting dependence on expensive oil imports for electrical power argues against the development of any sizeable, export-oriented ferrochromium industry.

#### **ALBANIA**

As noted in Figure III-1, Albania produces 1 million tons of chromite annually. It has averaged a similar output for nearly a decade, although reserves and resource estimates (Table III-2) do not seem capable of sustaining such long-term high level production. The ore occurs in podiform formations which must be easily mineable given the undeveloped nature of Albania's economy.

Complementing the sizeable ore deposits is a large potential for hydroelectric power. Foreign investment, up 8.4 percent in 1980, has been focused on mineral-related projects such as the 600 Mw hydroelectric project on the Drin River.<sup>7</sup> Given the importance of power availability to ferrochromium production, one cannot help but be impressed by Albania's potential. Yet, the two largest chromite mines, Martanesh and Bulqize, are not served by rail lines and the lack of skilled labor continues to be a problem in the wake of the Chinese pullout.<sup>1</sup>

Albania has enjoyed stable political leadership since 1944 when the current Communist Party leader, Enver Hoxha, assumed power. The nation is isolated in all respects, paranoid and closed to the outside world.<sup>1</sup> At 75, Hoxha's rule is nearing an end, and information is insufficient to suggest what course Albania would follow after his death.

Albania broke ties with the Soviets in the early

1960s, preferring the more devout communism approach of the Chinese. As a result, Albania does not participate in Comecon or the Warsaw Pact. Albania has now broken with China, forfeiting a major creditor and 2000 Chinese technicians.<sup>1</sup>

Its economic dependence on the export of chromite and apparently viable reserves should insure the continuation of supply into the foreseeable future. Under the current regime, it is unlikely that Albania would truncate chromite shipments due to U.S.-Soviet conflict.

Nevertheless, the Hoxha regime will soon pass into history and a rapprochement between Albania and the USSR or China must be considered possible. Albania must have foreign investment to develop its minerals potential and a new regime anxious to establish its legitimacy will likely move to insure minerals related inflows of capital. Regardless of the benefactor, it seems unlikely that Albania would long forego the expansion of its smelting industry. Currently, Yugoslavia provides 6 percent of the ferrochromium imports to the U.S. by processing Albanian chromite in out of date smelters (Table III-11). However, even if Albania seizes this opportunity, the potential political instability of the country makes the security of ferrochromium supplies from Albania, at this point in time, questionable.

#### INDIA

India has demonstrated a propensity to curb chromite exports in favor of domestic ferrochromium production. Will this trend continue and, if so, can the Indian supply be considered secure?

According to Dr. Bruce Lipin, the U.S. Geologic Survey expert on chromium, early results from the Orissa mineral exploration effort indicate the chromite reserves of India may be "substantially greater" than previously estimated.<sup>1</sup> Such a discovery, if verified, would remove a major constraint to the growth of the ferrochromium industry.

Ferrochromium has been produced by two companies. Ferro Alloys Corporation (FACOR) which has a 20,000 ton per year facility. A 10,000 ton per year smelter is operated by Visvesvaraya Iron and Steel Ltd. However, new investment is swelling India's capacity. The Orissa Mining Corporation is completing a \$37.5 million smelting facility. State owned, the plant will produce 50,000 tons of alloy annually. Other state and privately owned ferrochromium plants are being considered which could increase total annual capacity to 180,000 tons per year.<sup>7</sup>

There is however, a very real concern whether electric power capacity exists to support such a large smelting effort. Power shortages are chronic; in 1979 ferrochromium plants, at times, received only 25 percent of their needs.<sup>1</sup> Some industries produced only

seasonally, when monsoon rains filled hydro-reservoirs. Incredibly, India's coal reserves are 112 billion tons, 5th largest in the world.<sup>7</sup> India lacks the capital to effect coal energy development as a power resource or any industrial infrastructure for that matter. The following quote is from the U.S. Bureau of Mines' Minerals Yearbook, 1980:

Most industries, however, continue to be afflicted by labor problems, power shortages, and transportation constraints, as well as difficulties associated with obsolete plants and equipment. The poor performance of the Indian railroad system was a serious impediment to all industries.<sup>13</sup>

Owing to its erstwhile colonial status in the British Empire, India has, in spite of the pragmatic actions of its leader, strong cultural ties to the West. Internally, however, India faces enormous, divisive, problems. The population is the second largest in the world and its exponential growth threatens to outstrip food production. Administrative operation of the country is complicated by the fact that, as late as 1947, India was divided into 562 separate states.<sup>1</sup>

Geopolitically, India commands a dominant but increasingly isolated position in the Indian Ocean. Once India anchored a "Rimland" of nations which contained the Communist "Heartland" of Eurasia; but no longer. The fall of the "dominos" of South East Asia has weakened India's eastern flank. Although China's aggressiveness concerning

border disputes in the North has waned, China retains friendly relations with Pakistan, with which India fought a border war in 1965.<sup>1</sup> Beyond Pakistan to the West, the overthrow of the pro-Western regime in Iran and the Soviet invasion of Afghanistan greatly altered the geopolitical character of the Middle East and South Asia. At the same time, the Soviets have expanded naval activities in the Indian Ocean.

While India has the basic components of ferroalloy production, chromite and coal, it, as yet, lacks the infrastructure, investment capital and management to assimilate them into a competitive ferrochromium industry. There are two additional export-oriented ferrochromium smelters on the drawing board but one must seriously question their ability to obtain guaranteed power sufficient to make the supply of their product reliable. India is an underdeveloped nation of increasing geopolitical isolation. There is no doubt that in the short and medium term, India cannot be considered a major, reliable source of ferrochromium.

#### **SOVIET UNION**

The USSR consumes or stocks 70 percent of chromite production. Seventy-five percent of exports are shipped to central economy countries and the remaining small quantity of ore is marketed to the U.S. The decline in Soviet chromite exports in recent years is thought to be

caused by a supply disruption resulting from the transition to underground mining and delays in the commissioning of beneficiation plants to handle the disseminated chromite. Although energy self-sufficient, the Soviets have not demonstrated a trend toward accelerating ferrochromium production for export purposes. No Soviet ferrochromium is exported to the USA. Most processing of chromite occurs at the Donskoy facilities in Kromtau and near Cheliabinsk in the Urals. Annual ferrochromium production for late 1970s was reported to be near 220,000 metric tons.<sup>1</sup> No universally accepted figure of total capacity exists although the highest estimates place it near that of South Africa. The USSR is not considered as a chromite/ferrochrome import source to fulfill U.S. strategic import dependence needs.

#### **MINOR CHROMIUM PRODUCERS**

According to the BOM chromium analyst, numerous other countries produce minor amounts of chromium. It's noteworthy that all these nations plan capacity increases for their chromite and/or ferrochrome industry. The most ambitious expansion is planned by Iran, who intends to expand chromite mine production tenfold by 1986. Even though they have the oil needed for the energy-intensive ferrochrome industry; no plans to enter the ferrochrome industry were noted by the BOM.<sup>20</sup>

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## CHAPTER V

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## CHAPTER VI

### U.S. POLICY OPTIONS FOR POTENTIAL CHROMIUM SUPPLY DISRUPTIONS

#### INTRODUCTION

This chapter looks at typical chromium disruption scenarios postulated by U.S. government mineral analysts. Then it presents an analysis of policy options available to combat this lack of supply security for chromium. These options are in addition to the supply diversification options presented in the last chapter.

#### CHROMIUM SUPPLY DISRUPTION SCENARIOS

Disruption scenarios generally discuss the Republic of South Africa and Zimbabwe due to their production capacities and dominant control of reserves. A panel of mineral, economic and political specialists convened by the U.S. Bureau of Mines Office of Minerals Policy Analysis determined specific events which could cause a disruption in chromium exports from South Africa and Zimbabwe. Their proposals are representative of other scenarios presented by our government.

#### **South African Assessment<sup>1</sup>**

The panelists agreed that the course of South Africa's future was highly dependent on the effects of dealing with its racial issues. All scenarios are based on alternative resolution of this issue. Other issues were important primarily to the extent that they affected

or were affected by this central theme. Specific events which were considered within the context of various scenarios included the exodus of white managerial and technical workers, terrorism and sabotage, loss of unskilled labor, export embargoes, outside intervention, social structure breakdown and trade sanctions.

The following scenarios were developed by the panel members for South Africa:<sup>1</sup>

- 1) Continued control of central institutions by whites with some black resistance characterized by low to moderate levels of violence.
- 2) A mixture of protest, violence and negotiations leading to a decline of white control of government and an emerging power balance in the society.
- 3) Significantly expanded violence, with whites losing control of the process of political change. This scenario could lead to a partitioning of the country and/or outside intervention.
- 4) Early movement toward revolutionary violence and radical black takeover of government with possible outside intervention.

The panel assigned each of these scenarios a distinct probability of occurrence. Those scenarios that describe a continuation of a relatively stable political environment were seen as the most likely to occur, while Scenario 4, involving the most disruptive conditions, was

assigned a probability of occurrence of less than 0.1, or less than 10 percent.

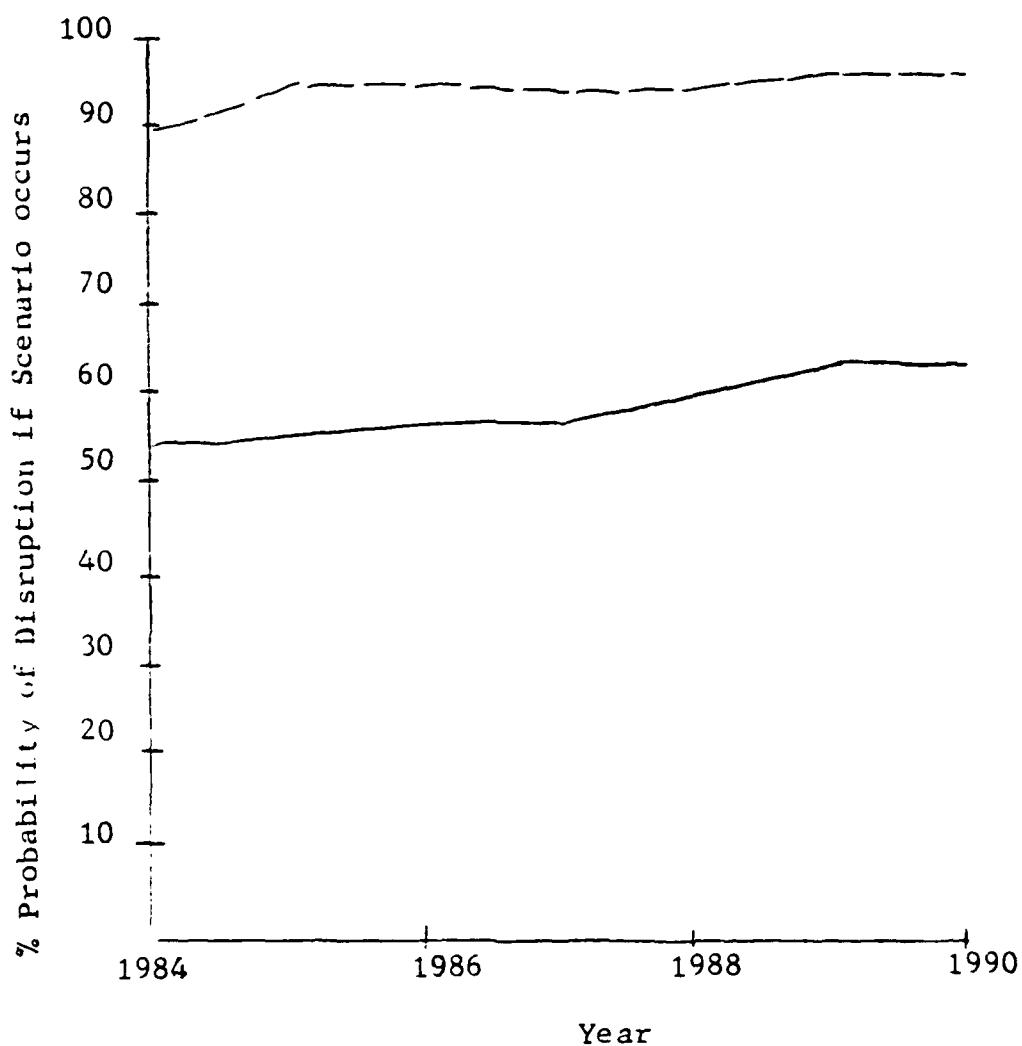
The set of conditions and events that describe each scenario determine the likelihood of a disruption of chromium exports, with the more severe disruptions are not likely to lead to a total cutoff of chromium exports.

The political assessment process, therefore, is a methodology for using the information generated by the panel to estimate the timing, magnitude and duration of possible disruptions. Figure VI-1 illustrates some important information derived from this process. The dashed line across the top of the figure corresponds to Scenario 4 (which has a low probability of occurrence). Should this scenario in fact be realized, the chance of a significant export disruption is very high - nearly 0.9 for every year from 1984 to 1990. Should any of the other scenarios occur, the probability of a disruption would be lower, with the more stable scenarios having the lowest probabilities of disruption. The solid line near the middle of Figure VI-1 stands for the overall probability level of a significant disruption, given that any of the scenarios might occur.<sup>1</sup>

#### **Zimbabwean Assessment<sup>1</sup>**

Racial questions were also considered important in the panel discussions on Zimbabwe, but only within the larger context of Zimbabwe's ability to deal with its

FIGURE VI-1  
PROBABILITY OF A SIGNIFICANT DISRUPTION  
OF SOUTH AFRICAN CHROMIUM EXPORTS, 1984 TO 1990



\*WORST SCENARIO

\*ALL SCENARIOS

SOURCE: 1

independence. Other important issues included the amount of economic aid received from western nations, the success of land reform, and the integration of armed remnants of revolutionary forces into the society. The disruptive events which were discussed included accelerated deterioration of productive equipment, terrorism and subversion, management and technical flight, loss of skilled labor, and blockades.

The following scenarios for Zimbabwe were developed by the panel members:<sup>1</sup>

- 1) Political stability and balanced development assisted by western aid.
- 2) Development of the mineral sector of the economy while other sectors decline (notably agriculture).
- 3) Political stability with general economic decline resulting from excessive Africanization.
- 4) Political instability leading to general breakdown of law and order with an increased potential for outside intervention.
- 5) Political instability leading to civil war with major potential for outside intervention and massive emigration.

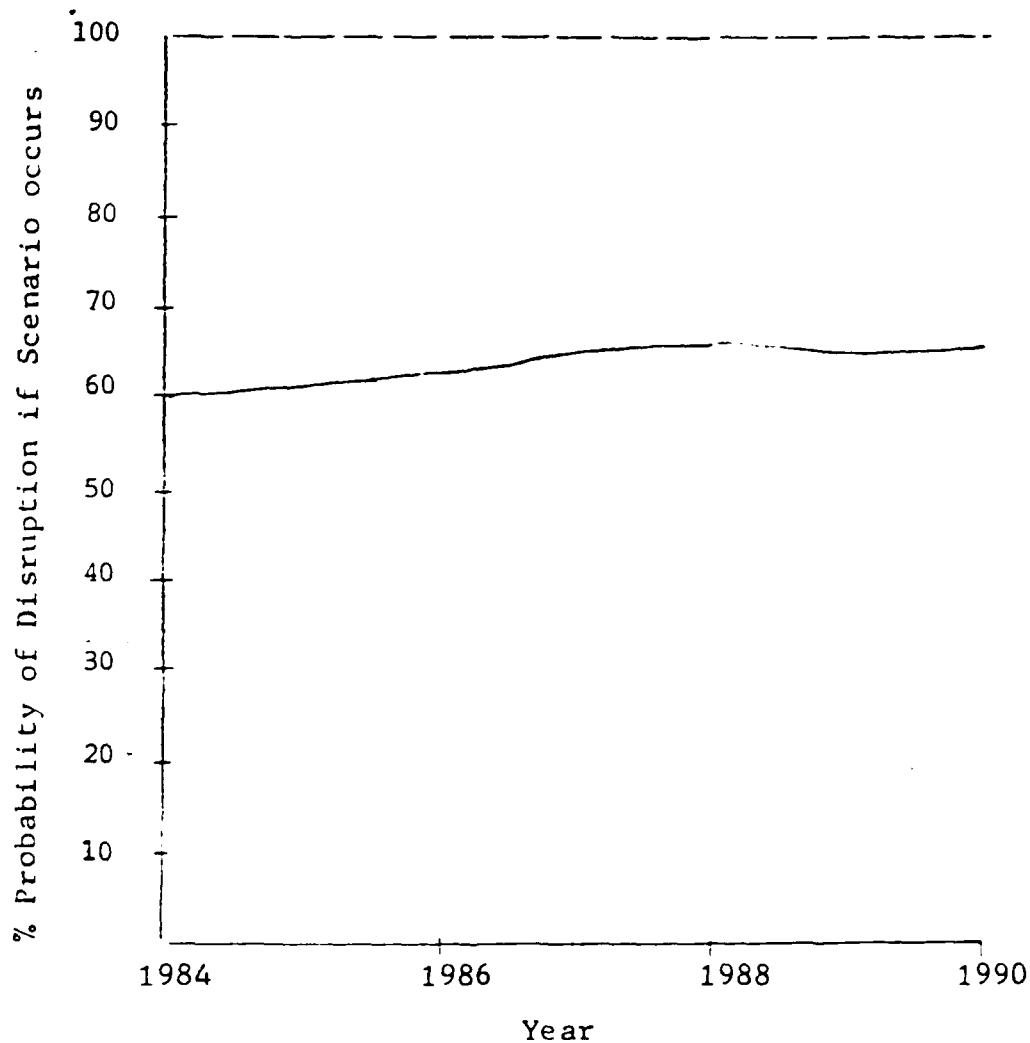
As was the case for South Africa, the most severe scenarios defined by the panel for Zimbabwe have the lowest probabilities of occurrence. Scenario 5, the most severe, has a probability of occurrence of less than 0.1,

or less than 10 percent. Should this scenario be the actual course of events for Zimbabwe, however, a significant disruption is almost certain. The dashed line across the top of Figure VI-2 shows the probability of a significant disruption of Zimbabwean chromium exports, given that the situation described under Scenario 5 becomes a reality. All other scenarios have lower associated probabilities of disruption. The solid line shows the average probability of disruption, given that any of the possible futures could occur. Note that the panel saw the chance of a disruption as greater for Zimbabwe than for South Africa, and in both countries, the probability of a disruption is greater late in the 1984-90 period.<sup>1</sup>

#### **Prepare for the Worst**

The probabilities shown in Figures VI-1 & VI-2 appear high since they are presented with the assumption that the worst scenario or an average of all the disruption scenarios does occur. This is not unusual for U.S. government-sponsored studies on critical minerals. They always seem to expect the worst. This can be traced back to the overriding theme of fear that was discussed at the end of Chapter II. Luckily, these feelings make us more likely to continue to deal with strategic mineral dependence and perceived vulnerability, rather than to ignore the issue. In order to face up to a continually

FIGURE VI-2  
PROBABILITY OF A SIGNIFICANT DISRUPTION  
OF ZIMBABWEAN EXPORTS, 1984 TO 1990



- \* WORST SCENARIO
- \* ALL SCENARIOS

SOURCE: 1

worsening chromium situation, the United States has two alternatives; we can wait for a crisis to develop and then react accordingly; or we can prepare for the worst.

#### **DISRUPTION POSSIBILITIES BY A CHROMIUM CARTEL**

Given the importance of the Republic of South Africa and the Soviet Union in the long-run success of a formal cartel in the chromite market, explicit OPEC-type collusion is highly unlikely. The United States is almost entirely dependent, except for stockpile releases, on chromite imports, and given the potential for instability of supplies from southern Africa and the Soviet Union, the major risk apparently is that of interruptions in supply from one or more major suppliers, very possibly followed by collusion among the remaining suppliers. Major producing countries other than the Soviet Union, South Africa, and Zimbabwe include Albania, Turkey, and the Philippines. While there are a number of minor suppliers, their expansion possibilities appear limited, except possibly for India and Brazil.<sup>2</sup>

Explicit collusion is unlikely for political reasons, and administering a chromite cartel would be difficult. The ore is highly heterogeneous, and demand depends on capital and durable-goods production, which fluctuate substantially. Reserve and production data indicate that market concentration may rise in the future, as the Turkish market share declines and, as the available

information suggests, Soviet exports decline; the long-run prospect is for increasing U.S. dependence on southern African production.

It appears that the Soviet Union and Turkey have tacitly cooperated in the chromite market.<sup>2</sup> However, the very large reserves of ore in southern Africa indicate that South African and Zimbabwean cooperation would be essential to the lasting success of restrictions in the chromium market.

Until recently, the major metallurgical uses of chromium generally required high-grade chromite of types available primarily from Turkey, the Soviet Union and Zimbabwe. The potential market power of these countries has been substantially reduced by the technological development of the argon oxygen decarburization (AOD) process, discussed in chapter 3. This development greatly increased the substitutability of South African low-chromium (chemical grade) ores in the metallurgical industry.

There have been no significant or concerted producer country actions in the chromite market, even when the UN sanctioned embargo on Rhodesian chromium occurred. Of course, that embargo did not seem to work as Rhodesian chromite and ferrochrome continued to enter the world market.

The primary supply concern for the United States

and our allies rests for southern Africa supply disruptions of chromite and ferrochrome, not the possibility of a chromium cartel.

However, not just a chromium cartel, but a strategic minerals supercartel has been postulated by Bohdan O. Szuprowicz in his book, How to Avoid Strategic Materials Shortages.<sup>3</sup> Table II-2 displays the strategic mineral reserves dominance a supercartel would hold. Szuprowicz discusses both Soviet and South Africa led control of southern Africa minerals production. With marxist governments already scattered throughout southern Africa, and the Soviet backed military presence in and around the region, the prospects for the formation of a COMECON supercartel are the most likely. However, this author suspects that the possibility is quite remote. U.S. vs. USSR conventional war would probably break out before the supercartel even materialized.

#### OTHER U.S. POLICY OPTIONS

Numerous other foreign policy options must be examined for chromium, as well as other critical and strategic minerals.

##### Stocks

This section deals mainly with the U.S. government National Defense Stockpile of chromium, although privately owned consumer stocks could prove more important during periods of supply disruption. However, since each company

makes individual decisions about their chromite or ferrochrome stocks based on their economic position, a generalized evaluation is almost fruitless. This author does not foresee the U.S. government subsidizing private firms to keep their consumer stocks at some minimum level.

Declines in domestic consumer stocks do seem to add to the U.S. vulnerability to import supply disruptions. During the late 1970's, in Japan, there was a major upward shift in average year end consumer stocks of ferrochromium. This corresponds closely with the increasing levels of ferrochromium imports into Japan over the period. Tables VI-1 and VI-2 show just the opposite for U.S. consumer stocks of ferrochromium and chromite. This is common during recessionary times, but potentially dangerous to the U.S. military-industrial complex.

Significant stocks of chromite and of ferrochromium are assumed to be held in South Africa and Zimbabwe, but little information is available concerning holdings in other major exporting nations. Reports detailing production and total sales of South Africa chromite over the 1972-79 period imply substantial production which is neither locally consumed nor exported. These surpluses have totalled about 2.1 million short tons chromium content for the eight years as a whole. This would represent nearly 2 years of South African production and over 6 years of South African exports at 1979 levels.<sup>5</sup>

TABLE VI-1  
U.S. CONSUMER STOCKS OF CHROMITE, DECEMBER 31  
(Thousand short tons)

<u>Industry</u>	<u>1978</u>	<u>1979</u>	<u>1980</u>	<u>1981</u>	<u>1982</u>
Metallurgical	755	416	219	230	120
Refractory	185	161	134	128	112
Chemical	<u>361</u>	<u>330</u>	<u>322</u>	<u>370</u>	<u>313</u>
Total	1301	907	675	728	545

Source: 4

TABLE VI-2  
U.S. CONSUMER STOCKS OF CHROMIUM FERROALLOYS  
AND CHROMIUM METAL, DECEMBER 31  
(Short tons, gross weight)

<u>Product</u>	<u>1978</u>	<u>1979</u>	<u>1980</u>	<u>1981</u>	<u>1982</u>
Low-carbon Ferrochromium	6455	6683	5432	5198	3459
High-carbon Ferrochromium	69196	45465	50258	46601	21793
Ferrochromium- Silicon	3492	3701	2578	1801	1237
Other 1	<u>2618</u>	<u>2465</u>	<u>1935</u>	<u>2468</u>	<u>2593</u>
Total	81761	58314	60203	56068	29082

<sup>1</sup>Includes chromium briquets, chromium metal, exothermic chromium additives, and other miscellaneous chromium alloys.

Source: 4

These producer stocks may now even be higher due to the worldwide recession, although both countries are just ending extended time periods of curtailed production well below capacity levels.

The United States also maintains substantial amounts of chromium materials in the National Defense Stockpile. This is the area where government policy can have the greatest strategic influence, generally at the lowest cost. In the past, changing stockpile criteria created supposedly large surpluses of government-held chromium, which were released over the 1966-77 period. These releases consisted primarily of chromite ores, but also included some 4,000 short tons of chromium metal. Their total volume in chromium content was substantial; in two different years, the U.S. Government sold an amount equivalent to over 25 percent of estimated annual U.S. industrial demand. The chromium content of remaining U.S. Government stocks totals nearly 1.5 million short tons, or about 2.6 years of domestic primary chromium consumption at 1981 levels.<sup>5</sup>

There has been concern about the quality and consumption of chromium holdings in the strategic stockpile. It is believed that the ferrochromium in the stockpile has sulfur limits exceeding those of current commercial grades. This could be circumvented, at some cost disadvantage, through the use of duplex melting and

refining processes by steelmakers. In addition, the low-carbon ferrochromium held in the stockpile may have excessive carbon and nitrogen contents by today's industrial requirements.<sup>5</sup> This could pose some difficulties for stainless and alloy steel producers should the material be needed in an emergency situation. A more serious concern has been raised with regard to the continued preponderance of chromite, as opposed to ferrrochromium, in the stockpile goals in the face of the increased U.S. reliance on offshore processing and imports of ferrochromium.

Table VI-3 provides the latest status of the U.S. chromium stockpile. When evaluating the chromium stockpile, one must also consider the chromite upgrade program reviewed earlier in chapter 4.

#### **Secondary Recovery**

In 1983, estimated chromium recycled in the U.S. increased to 20 % of chromium demand. However, this was influenced by an economic recession and is misleading. It is not that recycling was doubling, but that demand was falling dramatically. During economic prosperity, secondary chromium consumption in the U.S. has historically been about 10 percent of primary chromium consumption. But, according to Charles River Associates, it appears this supply would be very unresponsive to chromite price increases. Added recycling would only be

TABLE VI-3  
NATIONAL DEFENSE STOCKPILE OF CHROMIUM  
SEPTEMBER 30, 1983

<u>Commodity</u>	<u>Unit</u>	<u>Goal</u>	<u>Inventory</u>	<u>Value of Inventory (Millions\$)</u>
Chromium, Chemical & Metallurgical Group	ST Cr Metal	1,353,000	1,324,923	979.1
Chromite, Chemical Grade Ore	SDT	675,000	242,414	13.6
Chromite, Metallurgical Grade Ore	SDT	3,200,000	2,488,043	237.6
Chromium, Ferro, High Carbon	ST	185,000	402,696	238.4
Chromium, Ferro, Low Carbon	ST	75,000	318,892	418.0
Chromium, Ferro, Silicon	ST	90,000	58,357	43.3
Chromium, Metal	ST	20,000	3,763	28.2
Chromite, Refractory Grade Ore	SDT	850,000	391,414	42.6

Offsets: Metallurgical grade ore goal is 3,200,000 SDT of specification grade; inventory 1,956,824 SDT; shortfall 1,243,176 SDT.

- (1) Hold 217,695 ST of FeCr high carbon against shortfall of 544,238 SDT of specification grade ore.
- (2) Hold 243,892 ST of FeCr low carbon against 609,730 SDT of specification grade ore.
- (3) Hold 89,208 SDT of non-specification grade metallurgical ore against the balance of the 89,208 SDT specification grade ore shortfall.
- (4) Hold 47,466 SDT of non-specification grade metallurgical ore against a shortfall of 31,644 ST of FeCrSi.
- (5) Hold 56,830 SDT of non-specification grade metallurgical ore against a shortfall fo 16,237 ST of chromium metal.
- (6) Hold 337,715 SDT of non-specification grade metallurgical ore against 337,715 SDT of chemical grade ore shortfall.

Source: 6

responsive to severe supply disruption or sustained high prices.<sup>7</sup>

Most of secondary recovery, principally from stainless steel and scrap, is secured from manufacturing plants and dealers in obsolete material. Chromium recycling is very efficient in using scrap created during industrial processes; 78 percent of the "melt" used for heat and corrosion resistant alloys is derived from scrap. Recovery from manufactured products is much less efficient, and every year approximately 73,000 tons of chromium in scrap metal is lost. Only stainless steel scrap is a sizable source of supply.<sup>1</sup>

There exists a large hidden inventory of chromium contained in various industrial waste products such as dusts, slags, pickle liquors, and etching wastes, used refractories and consumer products containing stainless steels. However, the collection and processing costs hinder economic recovery on a large scale. Most of the nonmetallurgical uses for chromium are dissipative in nature, and little chromium can be recovered from recycling.<sup>8</sup>

Government studies (i.e. reference #1) have proposed some far-fetched subsidy programs to encourage greater chromium recycling. They are not economic policy alternatives and will not be included here. The key to recycling is economics. For instance, innovative

processing technology development and scrap reclamation is pursued in the ferrochromium superalloy industry because of the high value of those materials.<sup>8</sup> Though implementation may never be economically feasible, it is important that government and private industry take the lead in establishing contingency plans for increased secondary recovery. The Bureau of Mines chromium research program includes identification by source and quantity of chromium waste products as well as studies of processes to recover chromium in a useful product.<sup>8</sup>

#### **Substitution and Conservation**

According to a study published in 1978 by the National Materials Advisory Board (NMAB), about 34 percent of domestic usage of chromium could be saved by functionally acceptable chromium-free substitutes.<sup>9</sup>

Four percent could be saved after a short development period, while an additional 30 percent could be saved after an intermediate term research program of up to 10 years. However, the NMAB noted that 35 percent of the chromium usage was irreplaceable. Of this irreplaceable core of chromium products, stainless steel accounted for 59 percent.<sup>9</sup>

Stainless steels and superalloys are a vital component in all industrial processes involving high temperatures and pressures, and corrosive or oxidizing atmospheres, such as fossil fuel and energy conversion

processes. There is no economic substitute for chromium in stainless and high-strength steels, and as a component in industrial processes involving high temperatures and high pressure, such as the production of superalloys. However, a reduction in the chromium content of stainless steels is possible in some applications, and chromium-free substitutes are available for decorative stainless steels, automotive trim, flatware, refractories, and some chemicals. Both government and industrial research laboratories are investigating substitution possibilities to reduce requirements for chromium.<sup>9</sup>

Of the ferrous alloys, the greatest possibility here is to substitute a lower chromium stainless for a higher chromium stainless. For some applications, other alloys like aluminum or titanium may be substituted for stainless steel.<sup>8</sup>

As a class of materials, ferrous alloys, other than stainless steel, do not have a specified minimum chromium content. However, many particular steel alloys do specify chromium contents. In full alloy steels, boron, manganese, molybdenum, nickel, and silicon may substitute for chromium. In tool steels, chromium is essential and irreplaceable. For some applications, tool steel may be replaced by sintered carbides. In cast irons, boron, nickel, manganese, and molybdenum may substitute for chromium.<sup>8</sup>

In nonferrous alloys with nickel, iron-nickel, and cobalt, there are no satisfactory substitutes for chromium. However, there are satisfactory substitutes for chromium in most aluminum, titanium, and copper-base alloys. Zirconium and manganese may substitute for chromium in aluminum-base alloys. Molybdenum and vanadium may substitute for chromium in titanium base alloys.<sup>8</sup>

In the refractories industry, chromite is mixed with refractory magnesia to produce chrome-magnesite refractory bricks. The major use of these bricks is in steelmaking furnaces. Refractory bricks of low chromite-content or dolomite refractory bricks may be substituted for chromite-bearing refractory bricks.<sup>8</sup>

Chromium's two principal chemical uses--pigment and plating--are more susceptible to substitution than the metallurgical applications. Although chromium pigments have a well-established market, substitutes such as cadmium yellow, organic yellow, and yellow iron oxide pigments for chrome yellow are available, but with sacrifice in properties desired.<sup>8</sup>

There is no satisfactory alternative for chromium in industrial hard plating, but nickel, cadmium, and zinc may provide functional substitutes in some end-use applications.<sup>4</sup>

It should be pointed out that the United States is highly import dependent on many of these substitute

materials, like cobalt, aluminum, manganese, vanadium and columbium.<sup>10</sup>

So far, new substitution technologies have been the result of normal competition between materials and technologies on the basis of performance and price. They have thus come about slowly. With the stable prices, effectiveness of chromium, large worldwide reserves and large producer stocks currently found in the world chromium market, substitution policy will flounder at this time. However, the government and private sector need to be technologically prepared for substitution and conservation if chromium import disruption requires action.

#### **Research & Development**

Both substitution and conservation should currently be dealt with through research and development contingency plans. If supplies are disrupted, it is important that technology is available to implement substitution and conservation measures. This research should deal with all the ferroalloys, not just ferrochromium or chromite.

Government policies can encourage private sector research and development on conserving critical alloying materials and speed up the rate of industry acceptance of both short and long-term technical possibilities. In this, the process of encouraging technical changes in

chromium alloy use can be an important adjunct to the strategic stockpile in reducing supply vulnerability. The government role in accelerating conservation and substitution is primarily one of identifying what barriers can be removed and what incentives can be added without distorting the normal technical process. Maintaining the competitive nature of the process and providing a favorable climate for innovation includes such steps as improving the patent process, providing favorable tax treatment for various types of research, and reducing regulatory impediments. At present, steps are being taken to speed up the use of federally funded technology through a revised patent policy. In addition, a direct stimulus to private sector research, and increased funding for research by universities and private organizations, have been provided by the tax program. The ongoing regulatory reform program should improve regulatory cost-effectiveness and increase research funds and flexibility for industry.<sup>5</sup>

Another means of reducing barriers to innovation is facilitating joint research by firms on basic materials technology of benefit to the industry as a whole. Sharing the burden of research costs through collaborative research and development offers advantages over individual firm research in many cases. This is particularly true of materials science, which requires large investments of

research on basic technologies.<sup>9</sup> The Administration is now exploring mechanisms, such as Research and Development Limited Partnerships, which will allow collaborative industry research without involving the proprietary interests of competing firms and avoiding the antitrust problems of joint ventures. These arrangements would be privately financed and would use limited partnerships in the organization of large-scale research ventures involving end-users. They would also allow full utilization of tax incentives by limited partners.<sup>11</sup>

The Government also has a role in the collection and dissemination of technical information. Industry itself may not undertake to develop or compile data on conservation and substitution technologies which are not currently economic. The Government can collect information on practices which can lead quickly to reduced alloy use in an emergency, and make this available to industry through publications and seminars. It can also identify innovations in chromium alloy use which can improve industry competitiveness and reduce supply risks in the long run. The existence of a body of technical information could increase flexibility in industry use of materials, mitigate price increases in the event of disruption, assist in coherent coordination and planning by the private sector, and help identify gaps in knowledge and research activities.<sup>9</sup>

Steps could be taken to facilitate the commercialization of new materials technologies, particularly in regard to specifications and qualifications requirements. Steel specifications, which are formalized agreements on compositional limits for steel products, frequently lag behind technological changes and may overstate required alloy levels. The Government should work with the private sector in adjusting steel specifications for chromium alloying materials and in speeding the process of specification changes to allow increased conservation of chromium. Qualifications requirements for materials to be used in safety and defense uses may also be too stringent in certain cases. A review of the feasibility of streamlining some qualifications procedures may lead to a reduction of the cost burden on industry and speed materials innovations.<sup>11</sup>

There are also many areas of research where the Government itself needs to maintain an active role. The U.S. tradition of relying on market incentives to spur research and development tends to lead to an emphasis on short-term, low-risk investment in marginal product improvements, rather than long-term, higher risk investment in major technical innovations. Government materials research, therefore, should be oriented toward the longer-term and higher-risk research which tends to be

neglected by the private sector. This is true for both applied research important to national priority programs and the basic research areas necessary to the development of a scientific data base.<sup>11</sup>

Federal research activities should be coordinated with industrial needs and with industrial and university research activities. The research program should include the organization and expansion of basic knowledge on the function of the various alloying materials and the definition of their role in potential replacement alloys. It should encompass the development of alloy phase diagrams and basic information on new processing techniques for substitute alloys and alloys with vastly improved properties, such as rapid solidification, composites, and surface modification techniques. Another research area is the generation of fundamental information and data pertinent to the development of new steels and steels with improved performance through new melting, refining, and casting techniques, which also act to reduce alloy requirements.<sup>5</sup>

#### Tariffs

The tariff classification and rates of duty on chromite, ferroalloys and metal are shown in Table VI-3. The duties on high-carbon ferrochromium and ferrochromium silicon are not scheduled for reduction under the Tokyo Round agreements of the Multilateral Trade Negotiations

(MTN), while those for low-carbon ferrochromium and chromium metal are slated for decrease. Chromium metal and chromic oxide (or acid) are exempt from tariffs for certain less developed countries under the Generalized System of Preferences (GSP), although virtually all U.S. imports of these products come from developed countries not eligible for GSP treatment.<sup>5</sup>

TABLE VI-4  
U.S. IMPORT DUTIES ON CHROMIUM MATERIALS

<u>TSUS</u>	<u>Material</u>	<u>Most Favored Nation</u>	<u>Non-MFN</u>	<u>GSP</u>
		<u>1/1/84</u>	<u>1/1/87</u>	<u>1/1/84</u>
<u>1/1/84</u>				
601.15	Ore/ concentrate	Free	Free	---
606.22	LCFeCr	3.6%	3.1%	30%
606.24	HCFeCr	1.9%	1.9%	7.5%
606.42	FeCrSi	10%	10%	25%
632.18	Cr metal	4.4%	3.7%	30%
423.0092	Chromic acid	4.4%	3.7%	25% yes

Source: 12

Chromic oxide is the primary imput for aluminothermic chromium metal production. Several peculiarities with respect to the effective tariffs on chromium metal and chromic oxide have placed domestic producers at some disadvantage in supplying home market requirements. First, the U.S. tariff on chromium metal (4.4 percent) is much lower than that applied to imports of chromic oxide from the Soviet Union (25 percent), a

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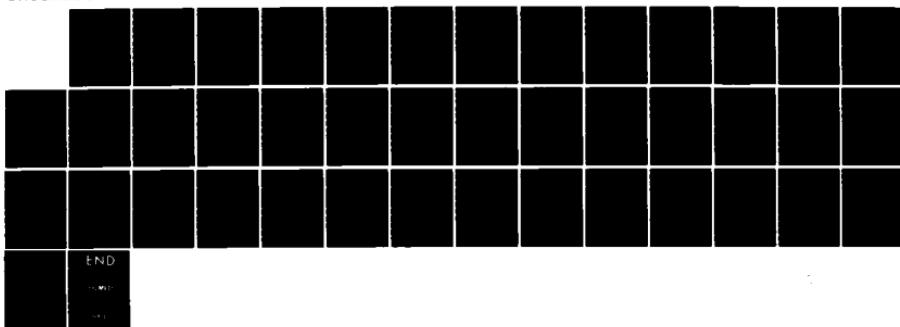
GEO POLITICS OF STRATEGIC MINERALS: THE EXAMPLE OF  
CHROMIUM(U) ARMY MILITARY PERSONNEL CENTER ALEXANDRIA  
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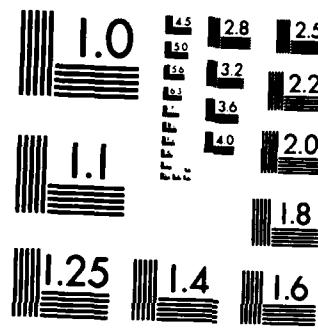
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NL



END  
MWP  
MPL



MICROCOPY RESOLUTION TEST CHART  
NATIONAL BUREAU OF STANDARDS-1963-A

major supplier, because the latter country faces our high non-MFN tariff rates. The high tariff U.S. chromium metal producers pay on imports of raw materials contrasted with the lower tariff protection they receive for their product actually encourages U.S. chromium metal imports. In addition, both the United States and its trading partners rebate 100 percent of the tariff on chromic oxide if the product is re-exported after processing. In this way, chromium metal producers in Western Europe incur no added tariff cost for chromic oxide used in the production of metal for export to the United States, while domestic producers are faced with the 25 percent duty as an added cost.<sup>5</sup>

The reader is referred back to the "Department of Commerce Recommendations" section of chapter 4 to review that HCFeCr imports were recently found to pose a national security threat. Still, they are subject to very low import tariffs. No actions were recommended by the Department of Commerce or taken by the President in May 1984 to increase these tariffs.<sup>13</sup>

An interesting breakpoint tariff proposal was suggested by the Ferroalloys Assoc. and presented in "The Preferable Solution" section of chapter 4.

#### **Domestic Production and Exploration**

As discussed early in chapter 3 in the "Domestic Chromite Potential" section, the economic feasibility of

mining domestic chromite is dubious.

Another method of reducing the vulnerability of the United States to future shortages of chromium would be to attack directly the developing problem of increasing geographic concentration of chromium ore resources. The United States has reduced its vulnerability in the past by diversifying production at home and abroad. This policy could be continued if additional exploration resulted in the discovery of new, high-quality ore deposits in areas of the world remote from southern Africa. It would not be necessary to develop these deposits. The mere fact of their existence would provide excellent protection against a long-term supply embargo (but not against a short-term supply disruption).

The preferred place to explore is the United States. It's a disgrace that the United States has not conducted a national inventory of strategic and critical minerals. Although the hopes for large chromite discoveries are slim, many states, especially Alaska, have not been adequately explored. The potential for other strategic minerals is much greater.

However, the size of the South African and Zimbabwean reserves essentially eliminates any incentive for additional exploration on the part of private industry. Thus, any additional exploration probably must be financed by the U.S. government, either directly or

indirectly. The involved exploration costs could be considerable, and high capital costs would be incurred if the new deposits had to be developed hurriedly in an emergency. Moreover, there is absolutely no assurance that additional exploration would uncover new, economically exploitable, ore deposits. Thus, although additional exploration might aid in reducing U.S. vulnerability, exploration alone would not provide a solution to the problem.

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## CHAPTER VII

### ELEMENTS OF POLICY OPTIONS INVOLVING SECURE SUPPLIES OF STRATEGIC MINERALS

#### INTRODUCTION

This chapter summarizes the thesis by providing specific conclusions and recommendations deriving for the example of U.S. chromium import dependence. Then, on the basis of what was learned from the chromium analysis, selected elements of mineral policy options are recommended for further study.

#### SUMMARIZING THE EXAMPLE OF CHROMIUM

The conclusions and recommendations presented are based on the author's reading and interpretation of a variety of sources, including references 1 and 2.

#### Conclusions

1. The sick status of domestic ferrochromium industry is a key area for concern. To operate a basic industry keyed to steelmaking, and therefore, essential to defense and important industrial applications, at somewhere between 0 and 20 percent capacity may inevitably lead to serious problems. Even worse, though the domestic steel industry recovered somewhat in 1984, the ferroalloy problem has intensified. A slow, 10 year, program to upgrade federally stockpiled chromite into ferrochrome, keeping one producer operational, is not enough. Government assistance is mandatory. This situation is even more

grievous than the potential for imported supply disruption.

2. Known chromium reserves are estimated at about 4 billion short tons and are expected to last for several centuries. On the basis of the currently known information, the quantity and location of proven and potential reserves are such that, at the current rate of consumption, the geographic concentration of chromium deposits will increase; within 25 to 75 years, the world will depend completely upon South African and Zimbabwean deposits.

3. U.S. chromium deposits are small and virtually no prospects exist for the discovery of any significant new U.S. deposits. On a global scale, there is little evidence to suggest the existence of significant chromium deposits outside of those geographic areas presently known. The discovery of additional deposits in producing regions with limited known reserves (e.g., the USSR and Turkey or elsewhere) would be beneficial in maintaining the few alternate sources of supply that currently exist, even if the new deposits were not developed initially.

4. Disruption of supplies from the Republic of South Africa or Zimbabwe has been forecast by numerous minerals analysts. Although disruption is not entirely inevitable, U.S. policymakers generally agree that the supply disruption threat for chromium requires policy changes and

improved contingency planning. The U.S. fears violent social change in southern Africa or intensification of Soviet influenced intervention in the South African region, where 95% of the world's chromite reserves are located.

5. No substitutes exist, or are likely to be developed, for chromium in the high-strength steels, high-temperature metals, and corrosion-resisting alloys that are essential in the manufacture of jet engines, petrochemical and power plant equipment, and various other critical products. It is highly unlikely that corrosion-resisting or high-strength alloy steels without chromium will be developed for such critical applications, although chromium-free substitutes could be used for decorative stainless steels, automotive trim, flatware, refractories, and some chemicals.

6. The criticality of chromium to U.S. industry generally is not appreciated, and this lack of awareness works against the development of long lead-time technologies, stockpiles, or international agreements necessary to avoid supply interruptions.

7. U.S. efforts to diversify their supply sources for chromite and ferrochromium, locking in the most secure supply sources with long-term contracts, have been inadequate.

8. U.S. efforts to prevent supply disruption from South

Africa and Zimbabwe need to be intensified through encouragement of social stability and economic success throughout the southern Africa region, especially Nambia and Zimbabwe.

9. The National Defense stockpile of chromium is the optimum response to the nation's perceived increasing vulnerability to a disruption of supply, providing short-term (about three years) protection. However, the quantity of ferrochrome stockpiled, especially HCFeCr, is inadequate.

10. A very limited potential for economic recycling (secondary recovery) still exists in various industrial waste products such as dusts and slags. However, recycling of consumer end products containing chromium, like stainless steel, is not economical in today's low priced chromium market.

11. Mandatory substitution and conservation in today's chromium market would result in severe economic dislocations.

12. Research and development (R&D) is the basis of an optimum economic response to the potential of long-term (greater than 5 years) supply disruptions of chromium. Government and private R & D should serve as the development work needed to implement substitution when supply disruption or increased chromium prices warrant such actions. The government and most firms are lacking

in this R & D field.

13. The Reagan Administration has taken some positive steps to decrease our vulnerability to ferrochrome supply disruptions, more than can be said for the previous five administrations in the past two decades. Still, especially for chromium, promises have been followed up by inadequate support programs.

#### **Recommendations**

Many of the references cited, especially the National Materials Advisory Board's Contingency Plans for Chromium Utilization,<sup>1</sup> provide technically detailed recommendations, while neglecting political and financial considerations. Just the opposite, the recommendations listed below attempt to give geopolitical and financial considerations a realistically valid emphasis. Only measures that are politically sound, economically feasible, and deemed absolutely necessary are recommended. Therefore, the recommendations are few in number, yet significant:

1. Impose a breakpoint tariff on HCFeCr imports. This is a drastic, yet necessary step. The domestic ferrochrome industry currently consists of seven producers, six of which are inoperative. Our domestic capacity will soon be lost, not just shutdown, if this industry is not put back to work. Upgrading the defense stockpile alone is not adequate. Congress needs to initiate this tariff, and

Americans must accept the reasonable increase in prices as a trade off for increased national security. Also, importing more chromite and less ferrochrome increases our options to import from diversified sources.

2. The criticality of U.S. dependence on foreign chromium should be publicized widely in conjunction with intentions to institute a program to decrease U.S. vulnerability to chromium requirements. Our legislators, particularly those from western mining states aware of strategic mineral import dependence issues, should strive to give the issue national priority attention. At a minimum, they need to stress domestic ferrochrome problems and educate our citizens as to our severe strategic mineral dependence on the Republic of South Africa, minimizing radical views for treating the South African apartheid problem.

3. Encourage social progress and aid economic success in southern Africa. This would suggest that the U.S. should strongly seek a settlement in Namibia and the economic success of Zimbabwe, and keep our relations correct, but necessarily distant from the current government in South Africa. Economic sanctions, or even discouragement of U.S. investment in South Africa, is probably not productive, but symbolic actions to indicate our disapproval of the apartheid system should be sought rather than avoided. Our ability to influence the rate of change in South Africa towards a multiracial society seems

to be quite asymmetrical - we can do more to slow the process than to speed it. Economic pressure on South Africa would not speed change. The disruptions in our supply of minerals are most likely to come about if change is violent and if present or future leaders of South Africa are unable or unwilling to take the measures necessary to retain skilled workers and professionals and to encourage production and investment.

4. Given the first recommendation, the national defense stockpile would be on track for chromium, provided methods have been initiated to periodically review the chromium stockpile and ensure that the contents of the stockpile are matched properly to changing U.S. needs.

5. A continuing major contingency in southern Africa could result in a shortage of chromite itself. To replace this shortfall, the flow of chromite from Brazil, Turkey, Finland, and a dozen other places could be expanded. Depending upon the circumstances and the price, additional supplies might also be forthcoming from the Soviet Union. The Philippines could be called upon for metallurgical as well as refractory ore. Breakpoint pricing would facilitate this replacement. Also, U.S. importers should study the benefits Japanese firms have reaped through diversifying supply sources and long-term contractual agreements.

6. A strong research and development budget is the most

economical way to be prepared to initiate greater recycling, substitution and conservation of chromium in U.S. industries to combat long-term supply disruption. Also, technology often leads to new processes that are immediately beneficial, like the AOD process enabled South Africa to be the world leader in the chromium market. President Reagan discussed this eloquently in his presidential news release on the subject.<sup>3</sup> In fact, some positive steps have been taken, especially by certain private firms. Still, much more should be committed to this area to assist the many U.S. basic industries that have had difficulties staying profitable in the 1980's.

In conclusion, this author sees money best spent on stockpile conversion, break-even tariffs, R & D and foreign aid to southern Africa. Other options like increasing defense stockpiles, subsidizing domestic production, import quotas, mandatory recycling, substitution or conservation are too costly considering the benefits to be derived.

#### **SELECTED ELEMENTS OF GENERAL POLICY OPTIONS FOR STRATEGIC MINERALS**

The United States has a considerable range of policy options to reduce its dependence on imported nonfuel minerals and limit the impact of any shortages that might result from such dependence. From a budgetary perspective, the least costly option would entail relying completely on the private sector to purchase the most

economical supplies and to maintain appropriate inventory levels, irrespective of whether the source was domestic or foreign. But that option could impose a high cost on the economy if a serious shortage were to occur, either as a result of a national defense emergency or as a result of other events affecting access to foreign sources of supply.

As the chromium chapters illustrate, the conditions surrounding the supplies of individual minerals vary widely. Significant differences exist concerning the nature and extent of risk involved in relying on imported supplies, the potential damage that might result from a contingency, and the ease with which the private market might adjust by resorting to consumption or supply alternatives. Many of the strategic minerals, including aluminum, chromium, cobalt, manganese, and the platinum group, share some risk of supply disruption from political instability, logistical difficulties, or attempts at price manipulation. The risk is particularly significant for those minerals produced principally in South Africa and the Soviet Union. While a variety of limiting circumstances would make disruption of these supplies less devastating than the oil shortages of the 1970s, any such disruption could exert real economic costs through losses of output and employment in industries that depend on foreign minerals.

Those options are examined which, if implemented, will seek to mitigate such costs:

1. Adjust the National Defense Stockpile;
2. Subsidize domestic production;
3. Diversify sources of supply;
4. Encourage exploration and development on public lands;
5. Intensify metals and materials research and development; and
6. Utilize foreign policy initiatives.

Since many of these policy options have, in fact been employed in the past, previous experience provides some guide to their effectiveness and cost. The following discussion of each option evaluates the factors likely to determine cost and effectiveness, as well as some difficulties of implementation and management.

#### **National Defense Stockpile Adjustments**

Stockpiles are named for their purposes. A defense stockpile is one intended for use only during time of war. An economic stockpile is a buffer stock, intended to smooth out shortages and sudden price runups arising from localized interruptions to individual minerals. For example, the Strategic Petroleum Reserve would presumably be made available at public auction under circumstances well short of warfare and thus could be considered an economic stockpile. Under current policy, the United States has a National Defense Stockpile of minerals and

materials intended to support defense production and essential civilian needs in time of national emergency. It does not have an economic stockpile that would bridge market shortages during other disruptions, such as the interruption of mineral production in one nation or region. An economic stockpile of strategic minerals has been determined as being too costly at the national level.

The National Defense Stockpile is both the first, and the most widely and repeatedly endorsed measure to minimize vulnerability to a wartime shortage of imported raw materials. The stockpile was initiated under the 1939 Strategic Minerals Act. Endorsed as the most cost-effective option by the Materials (Paley) Commission and subsequent panels, it has been virtually immune from criticism in principle.<sup>4</sup> Many claim, however, that it has not been managed well or used properly.

In principle, a stockpile could be built up during periods of low economic activity and accompanying low raw materials prices. Stockpiled materials would be released only during a national emergency, presumably when market demand and prices would be much higher. Depending on the time interval, profits from sales would offset part or all of the costs of management and storage as well as interest on government borrowing to finance purchases. The very existence of the stockpile should discourage potential aggressors who might hope to defeat the United States in a

conventional war by cutting off its supplies of vital raw materials and thus its defense production capabilities. But, in practice, several issues have been raised regarding the defense stockpile.

As discussed in Chapter 2, the minerals stockpile targets are developed by the Federal Emergency Management Agency. In an elaborate interagency process, the stockpile goals are determined based on assumptions about mineral demands during a three-year mobilization for war. This paper does not attempt to critique the 140 or so policy assumptions used to calculate the goals. The validity of the goals depends on the validity of these assumptions, however. Among the critical ones are the needs of the U.S. economy--both civilian and military--under mobilization conditions; probable increases in production in the United States, Canada, Mexico, and other secure sources; and levels of minerals consumption in other industrial nations.<sup>5</sup>

About \$11 billion in new appropriations would be required to meet all current goals at 1982 prices, of which about \$4 billion could be obtained by selling excess inventories.<sup>5</sup> But the \$11 billion figure includes purchases of minerals whose security risk is low. At current cash market prices, about \$1.4 billion would be needed to meet the goal for copper, \$600 million for nickel, \$800 million for zinc, and \$200 million for lead.<sup>5</sup>

The vulnerability of the United States to serious shortages of these metals, even in the event of a national emergency, can be questioned, given the extent to which U.S. needs are met from North American supply sources, the possibility for diversifying North American supply sources, and the possibility for expanding North American production rapidly. The extent of vulnerability in a national emergency for these and other minerals obtained from nearby sources of supply is a matter of judgment, as is the decision to pay fairly high insurance premiums for protection against low probability risks. Alternatively, stockpile procurement could be accelerated for those specific minerals for which substitutes would be difficult to find in an emergency and which are imported from relatively insecure sources--specifically South Africa, Zaire, and the Soviet Union.

Whatever goals may be deemed essential, any procurement would be most advantageous before economic recovery drives up raw material prices. Given the volatility of raw materials prices and the traditional movement of minerals prices over the business cycle, the cost of meeting defense stockpile goals could well increase by 50 percent or more if procurement is delayed until the international economy has reached its next cyclical peak.<sup>5</sup> The economy of most mineral producers lags behind the United States by 12-18 months.

### Subsidization of Domestic Production

Title III of the Defense Production Act (DPA) of 1950 authorized the President to guarantee loans and to take other financial steps to expand productive capacity and supply in the interest of national defense. Under this legislation, a \$2 billion authorization was enacted to meet shortages during the Korean War. Over the ensuing decade, this funding generated about \$8.4 billion in additional production. Aluminum production in the United States doubled, tungsten mining quadrupled, copper mining capacity increased by a fourth, domestic nickel and titanium production was developed, and foreign columbium-tantalum mining and processing facilities were greatly expanded. Over \$1 billion worth of materials acquired under this authority were sold to private users during the 1950s, at prices that recovered about 93 percent of the government's purchase cost.<sup>6</sup>

But, in general, the results achieved through the use of Title III authority were expensive. In addition to long-term purchase contracts at guaranteed prices, producers received direct subsidies (subsidized exploration costs and subsidized power for an aluminum producer, as well as direct payments for the production of columbium-tantalum, copper, and graphite), government guaranteed loans, loans at subsidized interest rates for new or expanded facilities, and very rapid depreciation

schedules for tax purposes. By mid-1959, stockpile inventories had been acquired by the government under the purchase contracts at the cost of about \$1.4 billion, but had an estimated market value of only \$843 million.<sup>5</sup> The inventories eventually became part of the strategic stockpile.

Cobalt, tungsten, titanium, columbium-tantalum, and manganese were all commodities for which the market value of DPA inventories in 1959 were 50 percent or less of acquisition costs.<sup>5</sup> Once the government purchase contracts were terminated, U.S. production of these materials ceased completely and have not resumed.

For a quarter of a century, Title III of DPA has not been used to support domestic production of nonfuel minerals, with the single exception of an \$83 million loan in 1967 to help develop a new copper mine.<sup>5</sup>

The possibility of using Title III of the DPA to subsidize the domestic mining industry now is uneconomical and remote. In the early 1950s, shortages and rapidly escalating prices in foreign markets jeopardized a needed rapid increase in defense production. The current defense buildup faces no such threat. The minerals industry--at home and abroad--is experiencing a sharp decline in production and employment, mine shutdowns, and considerable excess capacity.

Nevertheless, there might be cases when

competitive production capacity could be created with the help of some initial public financing. If the required federal subsidy was a low percentage of the market price, it might be preferable to bear this cost than to incur the expense of a three-year stockpile. But, this case would most often apply in metal industries that already have substantial domestic excess capacity and that pose the smallest security risks.

A corollary benefit of providing subsidies for expanding domestic production would be expanded capacity to meet peacetime contingencies. The likelihood of deliberate action by foreign governments to restrict the flow of raw materials to the United States would be reduced if U.S. mines and processing facilities had excess capacity or readily expandable capacity in place. If any contingency did arise, the impact on U.S. production and prices would be lessened to the extent that U.S. needs could be met more fully from domestic sources. However, these benefits must be weighed against the potentially significant cost of maintaining excess capacity, or even readily expandable capacity, in place.

Another corollary benefit would be assistance to the depressed U.S. mining and processing industry, its work force, and its communities. The very real problems of employees and communities could be addressed by other means, however, notably through retraining and assistance

in developing other community-based enterprises. It is difficult to justify production subsidy programs and excess capacity unless most of the cost is warranted as an efficient method of insuring the country against the risks of supply shortages.

#### **Supply Source Diversification**

Diversifying sources of supply would offer both U.S. metal-using industries and the producer-country greater assurance that damage from supply contingencies would be contained. For defense emergencies, of course, diversifying away from North American sources would make little sense unless supplies are not available in North America.

Since sea lanes within the Western Hemisphere are more likely to be safe, expanding Eastern Hemisphere sources could be less desirable. More numerous sources of supply, wherever they may be, also lessen the potential for development of cartels. On the other hand, diversification to countries controlled by potentially hostile regimes carries other risks, and unstable regimes offer little promise as reliable long-term suppliers.

For two decades after World War II, investments in foreign mines and foreign processing facilities were substantial, but most of the product was exported to Japan and European industrialized countries. The rest of the industrialized world expanded its metal-using industries

at a much faster pace than did the United States during this period. U.S. supplies of almost every imported material continued to come largely from a very few sources, as U.S. importers sought supplies at the lowest costs and were little concerned about reliability. Canadian mineral production expanded rapidly during this period, as did the variety of minerals produced there. Its exports were largely directed to the United States.

Events in the 1960's and 1970's focused attention on the relative reliability of suppliers, particularly in the Third World. As Japan's balance of payments improved, its early foreign investments were concentrated on acquiring new foreign materials supplies and diversifying its sources as much as possible. The U.S. minerals industry encountered more competition in its efforts to develop foreign production and more difficulty in finding a hospitable reception in the Third World. Australia and South and West Africa became centers for new minerals investment, attracted by an apparently more hospitable environment than existed in other areas with resource export potential.

Nevertheless, a relatively few foreign supply sources still predominate for almost every mineral. The U.S. government has very few means for inducing users of foreign materials to diversify their sources. The Western Hemisphere Trading Act did provide tax incentives for

private investment in the Western Hemisphere, but that legislation has expired. U.S. foreign investment incentives, including investment insurance, do not discriminate in favor of those areas that would represent additional diversification.<sup>5</sup>

Multilateral and bilateral aid programs and investment guarantees could reduce U.S. supply vulnerabilities by expanding and diversifying foreign production of critical and strategic materials. The aid programs would not need to finance minerals or metals processing investments directly. They could contribute to creating a climate in which private sector investments would be attractive, or they could finance infrastructure construction that would both promote private mineral investment and enhance other development. Such aid programs would increase budgetary expenditures only if aggregate aid levels increased. The investment insurance programs have been self-financing to date.<sup>5</sup>

#### **Access to Public Lands**

About one-third of the land area of the United States (some 734 million acres) consists of public lands, much of it designated as public parks, wilderness, and wilderness study areas. The President has stated that 40 to 68 percent of federal land is now estimated to be closed to minerals exploration and development.<sup>7</sup> Controversy has long persisted about whether these lands

should be preserved for recreational and aesthetic uses or opened for minerals exploration and development. Preservationists oppose exploration even by the government, lest development follow. Mining interests are reluctant to finance exploration unless mineral finds can be developed. As a result, the United States has hardly begun assessing the minerals potential of most public lands.

Knowledge that useful domestic resources exist could lead to their development during a contingency, though a high priority given to preservation could limit such use to situations of extreme severity and duration. Such knowledge could be obtained through more intensive exploratory surveys by the U.S. Geological Survey. Such surveys could lead to substantial mineral finds that might reduce the need to resort to much more expensive alternative provisions against contingencies.

#### **Research and Development**

Research and development (R&D) could reduce U.S. vulnerability to shortages of imported minerals and metals through contribution to improving every step of the extraction and industrial production process. In mining, it could enable the economic exploitation of lower quality ores, deeper mining, and the exploitation of smaller veins. It could facilitate more efficient processing and recycling, conservation of scarce minerals, and the

substitution of more available materials for those in scarce supply. Some resulting technologies might become economical even under normal supply conditions. Others could be held in reserve until supply shortages, and the ensuing price increases, made it feasible to incur the additional cost, as was the case for cobalt in 1978. Analyses of individual minerals, such as chromium present numerous examples of new technologies that have already become economical and are in use, or that would become so, if shortages led to significant price increases.

The federal government now accounts for about one-half of U.S. expenditures on R&D for minerals. Four percent of its R&D budget is devoted to funding 20 percent of the country's \$5.4 billion expenditure on R&D in this area.<sup>8</sup> These federal R&D expenditures, however, have been mainly for fuels and renewable resources rather than for nonfuel minerals. And most of the nonfuel mineral expenditures have been used for materials utilization, evaluation of materials properties, and the development of special materials substances derived from nonfuel minerals.<sup>9</sup> Basic resource development and processing have been relatively neglected. The Administration's proposed increase in fiscal year 1985 funding for the National Science Foundation, which promotes basic research, might reverse this trend. If not, the Congress might wish to consider legislation to promote R&D for nonfuel minerals

and metallurgical science.

The 80 percent of minerals R&D funded by private firms is designed to develop new products and/or increase their competitiveness. However, government funds are essential to help extend the base of scientific knowledge for substitution, conservation, and new materials applications. Private firms do underwrite some basic research, even though its results benefit competitors as well as themselves. That fact limits the funds that private firms can be expected to devote to this use, however.

Compared to the cost of acquiring and maintaining inventories or subsidizing production, research and development might prove inexpensive. If directed particularly toward those materials for which U.S. reliance on foreign sources entails some vulnerability, it could reduce risks considerably, as it has already.

#### **Foreign Policy and Diplomatic Initiatives**

If wars represent the failure of diplomacy, the same may be said of contingencies that might create serious shortages of critical and strategic monfuel minerals. Foreign policy requires setting priorities among competing national interests that constantly arise in dealing with foreign governments. U.S. interests in reducing vulnerabilities to raw materials shortages have often fallen by the wayside, sometimes because the issue

has not been adequately focused on and understood in the policymaking process. Nevertheless, if diplomacy was effective in reducing such vulnerabilities, the economic cost could be very low.

As noted in a recent study, foreign policy should be addressed to any or all of the following: facilitating new exploration and mining; protecting existing mining investment; encouraging political stability and unhampered flow of supplies to foreign markets; encouraging new governments to maintain and expand minerals production; discouraging foreign government support of private cartels or participation in restrictive inter-governmental agreements; diversifying sources of supply; and encouraging foreign governments to be dependable and reliable suppliers.<sup>10</sup>

Multilateral investment insurance is a promising instrument for encouraging more minerals exploration and development in the Third World. The idea was revived by the current president of the World Bank and endorsed by the U.S. government. The reluctance of many developing countries to participate in such programs has not received much priority in U.S. diplomatic relations with those governments. A higher priority for expanding minerals and metals productive capacity has only recently received much attention in the World Bank's lending program. An opportunity remains for stimulative efforts in U.S. policy

toward the World Bank and other multilateral lending agencies.<sup>5</sup>

From a materials vulnerability standpoint, the most important problems for U.S. foreign policy are those in central and southern Africa--South Africa, Zimbabwe, Gabon, Zaire, Zambia, Angola, and Mozambique. The achievement of independence in Zimbabwe has eased the problems of U.S. vulnerability to the interruption of chromium supplies from South Africa, but the reliability of its supplies would be much enhanced if they could be transported effectively and securely through Mozambique rather than South Africa.

Minority rule in South Africa remains a problem in U.S. relations with other African countries and is a source of continuing concern over the reliability of South African supplies, particularly for chromium, platinum, manganese, vanadium, and industrial diamonds. The present South African government is a reliable supplier and has every reason to remain so in the foreseeable future. However, if a successor regime took power under conditions that heightened resentment toward the United States for supporting the present regime, the country could become a much less reliable supplier. Its need for foreign exchange should be a mitigating factor, however, under most circumstances. A friendly successor regime could offer more durable protection for U.S. vulnerabilities.

The risk of peacetime supply interruptions might be more responsive to U.S. diplomatic efforts. A careful foreign policy review, focused on the sources of U.S. concern about materials vulnerability, and the possible means of mitigating the likelihood of an interruption or limiting its consequences, could suggest diplomatic efforts that might yield substantial benefits without significant cost to other U.S. interests. The financial cost of such a review and of the measures that it might suggest is unlikely to be large.

#### **CRITIQUE OF PRESIDENTIAL INITIATIVES CONCERNING STRATEGIC MINERALS**

When compared to its' predecessors, the Reagan administration can hardly be criticized for its actions on strategic minerals. Realizing the defense stockpile as our cheapest insurance policy against supply disruption, positive actions have centered on stockpile purchases and upgrading to required specifications. They have been slow, but a step in the right direction.

The Administration also deserves credit for prioritizing the need for long-term, high potential payoff, research and development to augment domestically available materials. However, funding has been less than suggested.

The funds Reagan has available to devote to these, and all other government programs, may be at the mercy of

payments to reduce the federal deficit, which has reached critical levels and now has top national priority.

The Administration's belief that private enterprise in a free market can preserve and expand our minerals and materials policy while diminishing import vulnerability seems somewhat narrow-minded and inaccurate. The ferrochrome case presented in chapter 4 is an excellent example. Domestic ferrochrome production went to zero while the economy was growing in early 1984. These types of emergency cases (i.e. steel, ferroalloys, copper, et al) need various types of financial assistance that the administration appears unwilling to provide.

Finally, the April 5, 1982, Presidential Program Plan on National Materials and Mineral Issues<sup>3</sup> was an initial step toward developing programs and organizations needed to implement the National Materials and Minerals Policy, Research and Development Act of 1980. However, after two years, one very serious flaw still exists, much as it always has existed for U.S. nonfuel mineral policy.

The plan assigned the important, yet historically neglected, responsibility for coordinating national minerals and materials policy to the Cabinet Council on National Resources and the Environment. As an aside, the famous Paley Commission of the 1950's also recommended a comprehensive cabinet-level agency.<sup>4</sup> However, a recent GAO investigation shows that the Cabinet Council has yet

to provide the continuous decision and policy coordination required by the act. Further, GAO investigators believe the Council lacks the breadth of expertise needed to address dynamic minerals and materials issues.<sup>11</sup> When dealing with over two dozen federal agencies, including the Departments of Commerce, Defense, Energy, Interior, the Office of Science and Technology Policy and the Committee on Materials (COMAT), a coordinator with decision-making power is essential.<sup>11</sup> Rectification of this situation by the President could do more for sound strategic minerals policy than any other government action of the past 30 years.

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